



## Ozone & Related Oxidants to Meet Essential Human Needs

Uses for Agri-Food, Industry, Water and Health

### International Conference & Exhibition

June 4 - 6, 2012

Ecole d'Ingénieurs de Purpan, Toulouse, France

by the European African Asian Australasian Group EA<sub>3</sub>G  
of the International Ozone Association IOA



Attending any IOA Event is the most effective way to keep current within the research and industry and to establish contact.

No other event delivers the sound science plus a showcase for new products, new services, new applications, and new solutions for ozone & related oxidants technologies.



## PROGRAMME

## BOOK OF ABSTRACTS



[www.ioa-ea3g.org](http://www.ioa-ea3g.org)



## WELCOME ADDRESS

The European African Asian Australasian Group of the International Ozone Association is organizing an International Conference & Exhibition entitled Ozone and Related Oxidants to Meet Essential Human Needs - Uses for Agri-Food, Industry, Water and Health in Toulouse, France. This event continues a long series of successful conferences organised to provide an international forum for all concerned with fundamental, engineering and applied aspects of oxidation techniques involving ozone and related oxidants. It is hosted by the Ecole d'Ingénieurs de Purpan.

The world's population is growing by about 80 million people a year and will reach 8 billion by 2030 with 60 % of urban dwellers. Together with population growth and urbanisation, growth in globalisation and wealth is forcing rapid changes such as industrialisation and extensive agriculture, these last in association with rising living standards and changing food and water consumption patterns. This unprecedented expansion poses an array of critical challenges related to the sustainable use of natural resources for provision of basic human needs such as safe drinking water, food, energy, materials, while protecting the environment and human health through adequate control of pollution discharge and development of green processes for the industry fields of agri-food, production & transformation process, energy and water treatment. This event will provide an overview of the current state of knowledge and latest advances regarding the use of ozone and related advanced oxidation systems for providing solutions to meet these goals.

The upcoming conference will host experts from all over the world to present and discuss the latest advances in knowledge and technology regarding the use of ozone and related advanced oxidation systems for providing solutions to Meet Essential Human Needs in Agri-Food, Industry, Water and Health.

We would like to express our gratitude and thanks to all of you who contributed to make this event possible: Ecole d'Ingénieurs de Purpan, authors, exhibitors, sponsors, Association' members, chairpersons and members of the Committees.

We wish you a very enjoyable and fruitful Conference.

On behalf of the IOA-EA<sub>3</sub>G Organising Committee,

Achim Ried  
IOA-EA<sub>3</sub>G President

### The Organizer and the Host



The International Ozone Association is a non-profit organization dedicated to the development of educational and scientific activities to respond at the best to the needs of industry and research community in the field of ozone and derived oxidants.

The Association operates through three Regional Groups. The EA<sub>3</sub>G Group manages membership and develop activities in Europe, Africa, Asia and Australasia.

Since its foundation in 1973, the IOA is at the forefront in connecting professionals around the globe involved and interested in ozone-related issues including scientists, researchers, engineers, system designers, technologists, equipment manufacturers, consultants, users and members of governmental agencies.

Typical topics covered in the activities program are ozone generation, secondary oxidant generation, gas mass transfer, chemical reactions of ozone in gas and liquid phases, engineering aspects, water treatment for disinfection and pollutants removal, oxidation for food processing, for pulp bleaching, for products manufacture and conditioning, development of analytical procedures and materials, development of equipments for ozone use, development and applications of advanced oxidation processes, safety and health effects.

For more information, please visit [www.ioa-ea3g.org](http://www.ioa-ea3g.org).

### Committees

#### > Programme Committee

M. Roustan, Chair (INSA Toulouse, France), R. Rice (RICE International Consulting Enterprises, USA), G. Chan (Université, Hong Kong), A. Pascual (AINIA, Spain), C. O'Donnell (Ireland), T. Curran (Ireland), F. Violleau (El Purpan, France), S. Baig (Degremont, France), Z. Do-Quang (Suez Environnement, France), F. Martin (Veolia Environnement RI, France), H. Debellefontaine (INSA Toulouse, France), W. Blogoslawski (National Marine Fisheries Service, USA), M. Oneby (MWH, USA), S. Pierson (Pierson Process Technology, USA).

#### > Organising Committee

S. Baig (Degremont, France), L. Bedos (El Purpan, France), A. Lasalmonie (IOA-EA<sub>3</sub>G, France), A. Ried (Xylem Wedeco, Germany), F. Violleau (El Purpan, France), Y. Chevelu (Alphatech, France), J-S Pic (INSA Toulouse, France), J. Albet (ENSIACET, France), M-H Manero (IUT, Université Toulouse 3, France), G. Altounian (Aquazon, France).



The Ecole d'Ingénieurs de PURPAN

(Purpan Engineers School) has strong agricultural and historical roots going back to 1919. Our research/lecturers

are strongly involved in helping students during both lectures and field trips. Our educational philosophy for individual success is based on personal mentoring. Our teaching staff is involved in consulting activities. PURPAN's laboratories and research teams develop scientific programmes designed to meet the expectations of businesses. PURPAN's excellence in this area is one of its main strengths. Our strong international presence is based on exchanges with numerous partner universities.

El Purpan belongs to a consortium of 4 Engineering Institutes, called the FESIA, Fédération des Ecoles Supérieures d'Ingénieurs en Agriculture, whose other members are ESA in Angers, ISA in Lille, and ISARA in Lyon. They all offer the possibility of building the same Engineering's level curriculum (French Diplôme d'Ingénieur corresponding to a Master's Degree) in different areas: Agriculture, Agribusiness, Food Industry, Environment and Land-use planning. Our Engineering degrees give access to PhD programme and are fully accredited by the French and International standards.

For more information, please visit <http://www.purpan.fr/en>.

## SPECIAL ACKNOWLEDGEMENTS AND CONTRIBUTIONS

The success in the organization of this event results from the strong involvement of many individuals and from the generous contributions of corporate sponsors.

The Organizers would like herewith to acknowledge the support given by the following partners:



- **Purpan Engineers School (France)**

*Conference Host*

**WEDECO**  
a xylem brand

[www.xylemwatersolutions.com](http://www.xylemwatersolutions.com)



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[www.ozonia.com](http://www.ozonia.com)

- **Xylem (Germany)**

*General Sponsor, Exhibitor*

We have accepted the challenge of the 21<sup>st</sup> century. With the WEDECO brand for UV disinfection and ozone oxidation, we own the advanced technologies for chemical-free and environmentally friendly treatment of drinking water, wastewater and process water as well as further industrial treatment processes. The broad outline of our business is to realize the best possible solution for mankind and the environment, as well as the most economic solution for our clients.

Committed, highly qualified experts in the research & development, production, sales, commercial and technical operations and customer service departments all contribute to the brand's success.

- **Airsep Corporation (USA)**

*Sponsor (Coffee breaks), Exhibitor*

Maximize ozone generator performance and life expectancy with AirSep PSA/VSA Oxygen Generators that produce oxygen flow rates from 0.45 - 3755 KG/HR. With over 28 years of experience AirSep systems offer the best, efficiency, value and performance in oxygen production

- **Ozonia (France)**

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OZONIA is the world leading supplier of OZONE. OZONIA provides equipment and systems for municipal and industrial disinfection as well as oxidation applications. Its product range includes for example standard ozone equipments and turn key plants.

- **Chart Industries (USA)**

*Exhibitor*



Bulk and packaged industrial gas customers throughout the world rely on Chart for solutions that increase efficiency and revenues while reducing costs. Whether you are a distributor of cryogenic gases or an end user with a particular cryogenic application, there

is a Chart product to meet your needs. And Chart employees have the skills and production capabilities to help with even the most challenging applications.

- **Alphatech (France)**

*Exhibitor*

Alphatech was create to answer the requirements of hygiene of the air and water always more important in food-processing industry. We propose you a very effective, reliable, economic solution and which allows you to delete or to decrease considerably your contaminations in bacteria, viruses, yeasts, molds, spores, and mushrooms

The ozone allows you to guarantee the cleanliness of your premises and of your zone of production; without traditional chemicals, by protecting the environment and by realizing important energy savings

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GLOBAL SECURITY SYSTEM

[www.alphatech-technologie.com](http://www.alphatech-technologie.com)

## GENERAL INFORMATION

### > Language

The official language will be English.

### > Conference venue



The Conference venue is Ecole d'Ingénieurs de Purpan, 75 voie du TOEC, BP 57611, 31076 TOULOUSE Cedex 3

#### Urban Transport

- Access from the centre of Toulouse: Subway line A direction «Basso Cambo», stop station «Arènes», connection to Bus n°64 direction «Colomiers Lycée International», stop «Grande-Bretagne».
- Access from PURPAN area: Bus n°64 direction «Arènes», stop «Grande-Bretagne».

#### Public transportation:

- Bus n°64: [www.tisseo.fr/sites/default/files/Tisseo\\_hiv64web.pdf](http://www.tisseo.fr/sites/default/files/Tisseo_hiv64web.pdf)
- Subway: [www.tisseo.fr/sites/default/files/Tisseo\\_hivMETROweb.pdf](http://www.tisseo.fr/sites/default/files/Tisseo_hivMETROweb.pdf)

Official website of the Toulouse Tourism Office: [www.uk.toulouse-tourisme.com](http://www.uk.toulouse-tourisme.com)

### > Registration categories

There are 7 categories of registration and associated fees as follows:

- • IOA or Purpan Member – Full registration
- • Non-member – Full registration
- • IOA or Purpan Member Student – Full registration
- • Non-member Student – Full registration
- • Conference dinner
- • Technical Tour
- • Accompanying person

The full registration fee covers scientific sessions, electronic proceedings, abstracts book, lunches, refreshments and city guided tour. A special discount rate is available for IOA members. Valid student ID is required for student registration. Additional registration is required for the Conference dinner and technical tour.

The registration for the Technical tour is opened to accompanying persons and guests.

The Accompanying person package includes the pass for guided city tour and the conference dinner registration.

### > Registration desk

It will be opened during the conference as follow:

- |                     |              |
|---------------------|--------------|
| • Monday, June 4    | 8:30 – 18:30 |
| • Tuesday, June 5   | 8:30 – 18:00 |
| • Wednesday, June 6 | 8:30 – 12:30 |

### > Badges

The wearing of a badge is compulsory inside Purpan building. They are necessary to access all scientific sessions and the city guided tour.

### > Coffee breaks

Complimentary coffee and drinks will be available at the scheduled break time.

### > Lunch breaks

Each day, lunch will be offered in the same building as the conference.

### > Liability and insurance

Registration for the Conference implies that the delegate agrees that neither the Organizers assume any liability whatsoever. Delegates are requested to make their own arrangements for medical, travel and personal insurance.

### > Disclaimer

The Organizers may at any time, with or without giving notice, in their absolute discretion and without giving any reason, change the Conference programme and withdraw any invitation to attend. In any case, neither the organizers nor any of their officers employees, agents, members or representatives shall be liable for any loss, liability, damage or expense suffered or incurred by any person, nor will they return any money paid to them in connection with the Conference unless they are satisfied not only that the money in question remains under their control, but also that the person who paid it has been unfairly prejudiced (as to which the decision shall be in their sole and unfettered discretion, and when announced, final and conclusive).

## GENERAL PROGRAMME

The three-day conference will feature scientific and technical presentations, poster presentations with introduction platform, discussions and networking opportunities. Near 50 presentations were selected by the Programme Committee and arranged according to the following sessions:

### Monday 4 June

8h30	Registration Opening
9h30-10h30	Introductory Conferences and Exhibition Opening
10h30	Coffee break
11h00-13h00	Session 1. Agri-food applications
13h00	Lunch
14h30-16h30	Session 2. Drinking Water Production
16h30	Coffee break
17h00-19h00	Session 3. Agri-food applications (cont'd) and Poster exhibition

### Tuesday 5 June

8h30-10h10	Session 4. Treatment of industrial wastewaters
10h10	Coffee break
10h40-12h30	Session 5. Poster session: oral introduction and exhibition
12h30	Lunch
14h00-15h50	Session 6. Fundamentals and engineering
15h50	Coffee break
16h20-17h20	Session 7. Micropollutant removal in urban wastewaters
18h00-20h00	Guided city tour (Departure 17h30, meeting point Donjon du Capitole)
20h00	Conference dinner – Brasserie Les Arcades

### Wednesday 6 June

8h30-10h00	Session 8. Urban wastewater treatment
10h00	Coffee break
10h30-11h20	Session 9. Sludge management
11h20-12h00	Closing ceremony
12h00	Lunch
14h00-18h00	Technical tour Wastewater Treatment Plant of Haute Vallée du Touyre at Laroque-d'Olmes

### > Publications and scientific awards

To encourage young researchers, the Programme Committee will select and award a prize to the best paper presented by a doctorate student during the Conference. All accepted papers will be printed in the conference proceedings that will be handed out to participants at registration. After the conference, the editors of the *Ozone: Science & Engineering Journal* will make the final selection among the papers presented for possible publication in this IOA peer-reviewed journal.

### > Conference dinner Tuesday 5, 20h00

Special registration required

Combining the luxury, the confort and the highest cuisine that characterize the greatest Parisian Brasseries, the Arcades lounges are set in the magnificent "Place du Capitole" in Toulouse. Whether for a group or an intimate meal, three thirties-styled rooms, with the same typical velvety charm, are awaiting you. Seven days a week, for lunch and dinner, Les Arcades will proudly delight you with their re-design of the most classical dishes of French gastronomy, regional specialities and flavours of the sea. This traditional Brasserie conceals thousands of refined pleasures.



#### Brasserie Les Arcades

14 place du Capitole - 31000 Toulouse  
Phone +33 (0)5 34 44 15 20

## > Cultural tours: Heritage Walk, Tuesday 5, 18h00-20h00



The organizing Committee booked a guided tour especially for congress participants and spouses for Tuesday 5, 18h00 - 20h00 just before the Conference dinner. The meeting point is Donjon du Capitole. Transfer will be organized by subway from the Conference Centre for the delegates.

This two-hour walking tour «Heritage Walk» will show everything you need to know to understand the identity of the «Pink City».

For your first visit to the city, this tour gives you a complete overview of the main sites and monuments. During the walk you can admire the Capitole (Town Hall) as you walk past it, the Saint-Sernin Basilica, a large number of churches and private mansions and, along the Garonne, some splendid views of Toulouse's flagship monuments. This tour includes entrance at the Jacobins. The Jacobins of Toulouse, situated in the city center, is constituted of a church, a cloister and a convent. The site, completely made out of bricks is considered as masterpieces of gothic art from the Languedoc region from the XIII<sup>th</sup> century and XIV<sup>th</sup> century. It is part of the listing of the ways to Santiago de Compostela:

After the visit, the group will dine in the typical restaurant Brasserie des Arcades nearby.

Registration is included in the full registration package for delegates and in the accompanying person pass. Wearing of walking shoes is recommended.

The Tourist Office of Toulouse offers a wealth of English guided tours that you can book online. See all details at <http://www.uk.toulouse-tourisme.com/sights-and-visits>.

## > Technical Tour: Wednesday 6, 14h00-18h00

### Wastewater Treatment Plant of Laroque-d'Olmes, Ariège

Special registration required.

At the heart of a small area traditionally dedicated to the textile industry, the river Outre suffered significant pollution, generated especially by the daily releases of dyes. To meet the discharge standards, 11 companies and 8 towns have formed the Association Syndicale Libre de ma Haute Vallée du Touyre (Free Trade Union of my Upper Valley of Touyre) to build this wastewater treatment plant with a capacity of 120 000 population equivalents.



The water system selected to simultaneously treat the industrial effluents and urban wastewaters include three complementary processes: a biological treatment of extended aeration type fed with pure oxygen, sand filtration and final ozonation. The objective of this facility, designed by Degremont, is to meet regulatory requirements by treating poorly biodegradable industrial effluents resulting from the massive use of dyes and finishing in the textile industry. The maximum flow rate of 25,000 m<sup>3</sup>/d. The discharge standards are set at 125 mg/L for COD and 100 mg/L of platinum-cobalt color. The advantage of ozone used for the first time in discoloration in France, is also to reduce non-biodegradable pollution without generating sludge. Ozonation involves 30 kg/h of ozone generated with 250 kg/h of oxygen. The ozone contactor contains 3 compartments in series to provide 40 minutes of contact time. The off gas is injected into the biological tanks using low pressure venturi system.



This tour will depart from and return to the Conference center. Special registration will be required. The fee will include bus transfer.

Visitors will have to provide copy of ID card or passport one month prior to visit. Wearing of trousers and closed-in walking shoes is recommended.

The Organisers reserve the right to cancel or limit attendance at any tour with monies refunded subject to minimum and maximum registration numbers.

## SCIENTIFIC AND TECHNICAL PROGRAMME

Monday 4 June 2012

### 9h30-10h30 INTRODUCTORY CONFERENCES AND EXHIBITION OPENING

- 9h30-9h50 Conference opening  
*A. RIED, IOA-EA<sub>3</sub>G President*
- 9h50-10h10 Food and Health and Food Safety: Current and Future Trends  
*J. DAYDÉ, Director of Research at the El Purpan, Facilitator Pole Food Health Safety Health (PASS) and Vice-Chairman of the Competitiveness Cluster Cancer-Bio-Health.*
- 10h10-10h30 Challenges to meet essential human needs: Why and what for ozone and related oxidants can serve  
*S. BAIG and M. ROUSTAN, IOA Past President and IOA-EA<sub>3</sub>G Vice-President*
- 10h30-11h00 Coffee break

### 11h00-13h00 SESSION 1. AGRI-FOOD APPLICATIONS – Chair: Daniel Smith

- 11h00-11h20 1.1 Study of the decomposition of pesticides by ozone: Innovative application for the treatment of downgraded loaded seeds  
*M. BOURGIN, J. ALBET, F. VIOLLEAU (France)*
- 11h20-11h40 1.2 Use of ozone in the control of soilborne pathogens and plant parasitic nematodes on tomato and eggplant  
*A. CICCARESE, M. GALLO, N. SASANELLI, L. MANCINI, F. CICCARESE (Italy)*
- 11h40-12h00 1.3 Investigation of potential ozone application in the processing of lettuce for pre-packed salads  
*P.J. SOLAN, A. O'REILLY, B.K. TIWARI, C. O'DONNELL, T.P. CURRAN (Ireland, UK)*
- 12h00-12h20 1.4 Study of the post harvest treatment of oranges with ozone and UV as an alternative to the use of chemical fungicides (*imazalil*)  
*A. CANUT, A. PASCUAL, M. VILLALBA, J. SALAS, R. SABORIT (Spain)*
- 12h20-12h40 Discussion
- 12h40-13h00 1.5 Ozone therapy of allergic rhinitis  
*T. BARKHOTKINA, R. TOMASHEVSKY (Ukraine)*
- 13h00-14h30 Lunch

### 14h30-16h30 SESSION 2. DRINKING WATER PRODUCTION – Chair: Tom Curran

- 14h30-14h50 2.1 Upgrade of Conventional Water Treatment Plants with Ozone to Reduce Formation of Chlorinated Disinfection Byproducts  
*M. ONEBY, J.H. BORCHARDT, R. LIN (USA)*
- 14h50-15h10 2.2 Ozone automation challenges and solutions  
*K.L. RAKNESS (USA)*
- 15h10-15h30 2.3 Bromate formation mitigation in an Australian water high in bromide  
*C. JAKUBOWSKI, C. CONWAY (Australia)*
- 15h30-15h50 2.4 Innovative integrated approach based on differential metabolomic profiling and estrogenic activity testing to reveal and identify biologically active by-products of estrone-sulfate after ozonation of drinking water  
*M. BOURGIN, G. GERVAIS, E. BICHON, J.P. ANTIGNAC, F. MONTEAU, G. LEROY, L. BARRITAUD, M. CHACHIGNON, V. INGRAND, P. ROCHE, B. LE BIZEC (France)*
- 15h50-16h10 2.5 Application of oxidation processes for membrane fouling control in seawater  
*Y. PENRU, S. ESPLUGAS, S. BAIG (Spain, France)*
- 16h10-16h30 2.6 Ozone disinfection efficiency of resistant microorganisms assessed at a drinking water treatment plant by combining inactivation kinetics and computational fluid dynamics  
*P. TALBOT, L. MARTINELLI, S. TALVY, E. CHAUVEHEID, B. HAUT (Belgium)*
- 16h30-17h00 Coffee break

### 17h00-19h00 SESSION 3. AGRI-FOOD APPLICATIONS (Cont'd) – Chair: Frédéric Violleau

- 17h00-17h20 3.1 Effect of ozone treatment on microorganisms viability evaluated by flow cytometry and plate count technique  
*E. SARRON, T. AUSSENAC, N. COCHET, P. GADONNA-WIDEHEM (France)*
- 17h20-17h40 3.2 Catechin in tea seed oil from *Camellia oleifera* Abel  
*J. SINGKHORAT, N. SUEALEK (Thailand)*

17h40-17h55	<b>3.3 Disinfection of plastic pockets for food packaging with ozonated water</b> <u>Yann CHEVELU</u> (France)
17h55-18h10	<b>3.4 Disinfection of atmosphere and surfaces with some gaseous ozone</b> <u>Yann CHEVELU</u> (France)
18h10-18h15	<b>3.5 Decontamination of treated wheat seeds by ozonation</b> <u>L.V. HOANG, C. COSTE, T. AUSSENAC</u> (France)
18h15-18h20	<b>3.6 Investigation of the potential use of ozone as an alternative to chemical treatment of medicated straw</b> <u>P.J. SOLAN, V. VALDRAMIDIS, C. ANDRONY, B.K. TIWARI, C. O'DONNELL, G. OWENS, A. G.M. SCANNELL, T.P. CURRAN</u> (Ireland, France, UK)
18h20-18h25	<b>3.7 Total unsaturation (TU) as control method for ozone's reaction with vegetable oils</b> <u>P. GUERRA BLANCO, T. POZNYAK, I. CHAIREZ, I. CÓRDOVA R.</u> (Mexico)
18h25-19h00	Poster exhibition

## Tuesday 5 June 2012

### 8h30-10h10 SESSION 4. TREATMENT OF INDUSTRIAL WASTEWATERS – Chair: Sylvie Baig

8h30-8h50	<b>4.1 Decomposition of toxic organics in waste water of the pulp and paper industry by ozonation and biodegradation</b> <u>J. AMACOSTA CASTILLO, T. POZNYAK, S. SILES ALVARADO</u> (Mexico)
8h50-9h10	<b>4.2 Treatment of bio-recalcitrant wastewater by coupling ozone and activated carbon</b> <u>T. MERLE, M.H. MANERO, J.S. PIC, H. DEBELLEFONTAINE</u> (France, Saudi Arabia)
9h10-9h30	<b>4.3 Oxidative regeneration of toluene saturated natural zeolite by gaseous ozone: effect of zeolite chemical surface characteristics</b> <u>S. ALEJANDRO, H. VALDÉS, M.H. MANÉRO, C.A. ZAROR</u> (Chile, France)
9h30-9h50	<b>4.4 Regeneration of coked zeolite by ozonation</b> <u>S. KHANGKHAM, C. JULCOUR, S. DAMRONGLERD, C. NGAMCHARUSSRIVICHAI, M.H. MANÉRO, H. DELMAS</u> (France, Thailand)
9h50-10h10	Discussion
10h10-10h40	Coffee break

### 10h40-12h30 SESSION 5. POSTER SESSION – Chair: Michel Roustan

10h40-10h45	<b>5.1 Photodegradation and photooxidation of phenylarsonic acid in aquatic solution</b> <u>M. CZAPLICKA, Ł. BRATEK, K. JAWOREK</u> (Poland)
10h45-10h50	<b>5.2 Kinetic study of the process Ad / Ox to the removal of phenol using different operational variables</b> <u>I. ALEGRÍA, J.I. LOMBRAÑA, F. VARONA, A. MENDILIBAR, S. SALVADOR, J. SANZ</u> (Spain)
10h50-10h55	<b>5.3 Petrochemical effluents treatment via advanced oxidation process: zeolites reactivity toward ozone and 2,4-dimethylphenol</b> <u>W. ABOUSSAOUD, M.H. MANERO, J.S. PIC, H. DEBELLEFONTAINE</u> (France)
10h55-11h00	<b>5.4 Advanced oxidation process in hospital wastewater treatment</b> <u>K. GONZALEZ LABRADA, I. QUESADA PEÑATE, U. JAUREGUI HAZA, C. JULCOUR, C. ANDRIANTSIFERANA, M.H. MANÉRO, C. MARTIN, H. BUDZINSKI, E. GENESTE, C. ALBASI</u> (France, Cuba)
11h00-11h05	<b>5.5 Computer Simulation of Advanced Oxidation Processes by Ozone and Hydrogen Peroxide</b> <u>A. IGNATEV, A. PRYAKHIN, V. LUNIN</u> (Russia)
11h05-11h10	<b>5.6 Effect of soil physical properties on the decomposition dynamics of phenanthrene by ozonation</b> <u>J. AMACOSTA CASTILLO, J. RODRIGUEZ, T. POZNYAK, A. GARCIA, C. GOMEZ, I. CHAIREZ</u> (Mexico)
11h10-12h30	Poster exhibition
11h30-12h30	Exhibit corner
12h30-14h00	Lunch

### 14h00-15h50 SESSION 6. FUNDAMENTAL AND ENGINEERING – Chair: Hubert Debellefontaine

14h00-14h20	<b>6.1 Thermally enhanced UV/H<sub>2</sub>O<sub>2</sub> application to a high loaded surfactant effluent</b> <u>J. SANZ, J.I. LOMBRAÑA, A. M. DE LUIS</u> (Spain)
14h20-14h40	<b>6.2 Screening of new catalysts for the development of advanced oxidation process combining ozone and zeolites or mesoporous materials</b> <u>J. VITTENET, J. MENDRET, S. BROSILLON, A. GALARNEAU</u> (France)

14h40-15h00	<b>6.3 Phenol oxidation in a semi industrial ozone pilot plant: the effects of some operating parameters</b> <u>V. ACHA</u> , L.V. HOANG, A. BAK, R. MARION, O. POURRET (France)
15h00-15h20	<b>6.4 Comparative analysis of the effect of pH on adsorption process of ozonation (Ad/Ox) for the removal of phenol</b> <u>I. ALEGRÍA</u> , <u>J.I. LOMBRANA</u> , F. VARONA, J. SILVA, J. SANZ (Spain)
15h20-15h40	<b>6.5 Catalytic ozonation of benzoic, phthalic and 2,4-dichlorophenoxyacetic acids in water: Effect of NiO concentration</b> <u>D. MAGALLANES</u> , <u>J.L. RODRÍGUEZ</u> , T. POZNYAK (Mexico)
15h40-15h50	Discussion
15h50-16h20	Coffee break
<b>16h20-17h20</b>	<b>SESSION 7. MICROPOLLUTANT REMOVAL IN URBAN WASTEWATERS – Chair: Florencio Martin</b>
16h20-16h40	<b>7.1 Removal of micro pollutants from municipal waste water – already "State of the art"? (A review on Europe's activities)</b> <u>J. MIELCKE</u> , <u>A. RIED</u> (Germany)
16h40-17h00	<b>7.2 Microcontaminant removal from municipal secondary effluents by ozonation</b> <u>R.F. DANTAS</u> , A. CRUZ, B. BAYARI, C. SANS, S. ESPLUGAS (Spain)
17h00-17h20	<b>7.3 Evaluation of advanced oxidation processes for the reduction of refractory micropollutants in treated wastewater</b> <u>S. BESNAULT</u> , S. MARTIN RUEL, S. BAIG, B. HEINIGER, M. ESPERANZA, H. BUDZINSKI, C. MIÈGE, M. COQUERY (France, Switzerland)
17h30	Departure for the city guided tour

### Wednesday 6 June 2012

#### 8h30-10h00 SESSION 8. URBAN WASTEWATER TREATMENT – Chair: Achim Ried

8h30-8h50	<b>8.1 Advanced Treatment of Tertiary Effluent with Ozone</b> <u>M. ONEBY</u> (USA)
8h50-9h10	<b>8.2 Assessing WWTP effluent organic matter conversion during ozone and UV/H<sub>2</sub>O<sub>2</sub> treatment using multiple surrogates</b> <u>W.T.M. AUDENAERT</u> , D. VANDIERENDONCK, S.W.H. VAN HULLE, I. NOPEN (Belgium)
9h10-9h30	<b>8.3 Benefits of ozonation as pretreatment of membrane filtration</b> <u>B. DOMENJOURD</u> , S. ESPLUGAS VIDAL, S. BAIG (Spain, France)
9h30-9h50	<b>8.4 UV and UV/Chlorine Advanced Oxidation Processes for food safety</b> <u>R. VAN ESCH</u> , K. ANDRE, C. SICHEL (Netherlands, Germany)
9h50-10h00	Discussion
10h00-10h30	Coffee break

#### 10h30-11h30 SESSION 9. SLUDGE MANAGEMENT – Chair: Michael Oneby

10h30-10h50	<b>9.1 Full-scale ozonation to reduce filamentous sludge at Klagshamn WWTP</b> <u>F. NILSSON</u> , K. JÖNSSON, J. DIMITROVA (Sweden)
10h50-11h10	<b>9.2 Ozonation Impacts on Waste Activated Sludge</b> <u>P. KIANMEHR</u> , W. PARKER, P. SETO (Canada, UAE)
11h10-11h20	Discussion

#### 11h20-12h00 CLOSING CEREMONY

12h00-14h00	Lunch
<b>14h00-18h00</b>	<b>Technical tour Wastewater Treatment Plant of Haute Vallée du Touyre at Laroque-d'Olmes</b>

## INTRODUCTORY CONFERENCES

### Conference opening

A. RIED, IOA-EA<sub>3</sub>G President

### Food and Health and Food Safety: Current and Future Trends

J. DAYDÉ, Director of Research at the El Purpan, Facilitator Pole Food Health Safety Health (PA3S) and Vice-Chairman of the Competitiveness Cluster Cancer-Bio-Health.

### Challenges to meet essential human needs: Why and what for ozone and related oxidants can serve:

S. BAIG and M. ROUSTAN, IOA Past President and IOA-EA<sub>3</sub>G Vice-President

## SESSION 1. AGRI-FOOD APPLICATIONS

### 1.1 Study of the decomposition of pesticides by ozone: Innovative application for the treatment of downgraded loaded seeds

M. BOURGIN, J. ALBET, F. VIOLLEAU (France)

Every year in France, seed producers must downgrade more than 12,000 tons of seeds. These seeds are currently incinerated in cement factories at seed producers' expenses and non available for the processes of valorization of renewable resources, due to their significant pesticide content. Consequently, the quantity of pesticides present in the seed loading must be reduced before a subsequent valorization of the downgraded seeds. The purpose of this work is thus to develop a process for the decomposition of a large amount of the pesticides present in the seed loading. Ozonation was proved to be efficient in wastewater treatment for the removal of pesticides of interest, usually present in the seed loading. Consequently, ozone was applied to soft wheat seeds loaded with Gaucho Blé<sup>®</sup> loading solution, in a fixed bed reactor. The humidification of seeds before ozonation, the concentration of ozone in the inlet gas and the ozonation time were revealed to be the predominant factors to accelerate the kinetic of degradation of pesticides in the seed loadings. In optimal conditions, pesticides were successfully decomposed (respectively 99 and 90 % for the degradation of imidacloprid and bitertanol, within 96 min of treatment). The kinetic laws for the ozonation reactions of imidacloprid and bitertanol were also determined and the partial orders of the reaction were 1 for both ozone and the pesticide. The subsequent application of this process for the treatment of other loaded seeds showed good degradation yields for all the studied pesticides and demonstrated the interest of such a process for the removal of pesticides on loaded seeds.

### 1.2 Use of ozone in the control of soilborne pathogens and plant parasitic nematodes on tomato and eggplant

A. CICCARESE, M. GALLO, N. SASANELLI, L. MANCINI, F. CICCARESE (Italy)

According to the necessity to find new eco-compatible control methods, against soilborne pathogens and plant parasitic nematodes, as required by the guidelines of European Community on the use of pesticides on agricultural crops, two experiments were carried out to verify the efficacy of ozone treatments, as gas and/or ozonated water, against the soil borne pathogens *Pyrenochaeta lycopersici* and *Verticillium dahliae* and the root-knot nematode *Meloidogyne incognita* on tomato and eggplant, respectively. In both experiments ozone treatments significantly reduced root gall index and soil nematode population density in comparison to untreated controls. Also severity of symptoms of the diseases caused by *P. lycopersici* and *V. dahliae* were significantly reduced.

### 1.3 Investigation of potential ozone application in the processing of lettuce for pre-packed salads

P.J. SOLAN, A. O'REILLY, B.K. TIWARI, C. O'DONNELL, T.P. CURRAN (Ireland, UK)

The minimal processing of lettuce (*Lactuca sativa*) and other vegetables used for pre-prepared 'salad mix' make it difficult to ensure that these fresh produce are safe for consumers. Chlorine-based cleaning agents are widely used to sanitise produce and reduce microbial populations. However, chlorine is not without its drawbacks; i.e. the limited efficacy of chlorine-based agents, residual chlorinated organic compounds with potential carcinogenic action and the limited antimicrobial efficacy outside of pH range 6-7.5. Thus there is a need to investigate the effectiveness of alternative cleaning techniques. Ozone has been recognised for years as a highly efficient oxidising agent with no risk of residues post treatment. The objective of this comparative study was to investigate the physical effects of ozone on chopped lettuce. Lettuce leaves were subjected to three wash treatments, A. conventional chlorine rinse (100 ppm) B. ozone in water (2.4 ppm) and C. control (water), over a 14 day period (typical shelf life). The physical parameters measured included colour, pH, and texture, while the microbial analysis involved using the viable plate count method of enumerating microbes. Preliminary results indicate that ozone treatment offers an alternative safe method for sanitizing lettuce. No significance difference was observed in the texture of the lettuce throughout the duration of the study. A slightly elevated pH was observed in the ozone treated samples towards the end of the 14 day period. As expected there was a notable lightening in the colour of the ozone treated lettuce leaves, with peripheral browning of the leaves recorded in the later stages of the study.

### 1.4 Study of the post harvest treatment of oranges with ozone and UV as an alternative to the use of chemical fungicides (imazalil)

A. CANUT, A. PASCUAL, M. VILLALBA, J. SALAS, R. SABORIT (Spain)

Post harvest treatment of citrus in the handling, processing, storage and marketing facilities rely on the application of chemical fungicides such as imazalil on the surface of the fruits in order to extend the shelf life of the product to avoid fast fruit decay due to blue and green moulds. Nevertheless these operations imply the presence of fungicides in the wash waters discharged and on the surface of the oranges sent to the markets. Environmental and food safety concerns and a growing demand of oranges completely free of residues of pesticides push for the development of greener and safer alternative post harvest treatments. This study compares, at pilot scale, the efficiency of using ozonated water followed by UV radiation as post harvest treatment of oranges in front of using fungicides. Considering the results obtained it is concluded that the use of ozone and UV is as efficient as Imazalil in preventing mould formation after 21 days of conservation of the oranges after the treatment (14 days at 5°C and 7 days at 21°C) without any deleterious effect on the quality of the fruits.

### 5.7 Ozone therapy of allergic rhinitis

T. BARKHOTKINA, R. TOMASHEVSKY (Ukraine)

In this article are presented questions of an etiology and pathogenesis allergic rhinosinusitis. The characteristic of a current state of medicamentous treatment of the given pathology is given. Are presented own schemes of diagnostics and treatment allergic rhinosinusitis with use of various techniques ozone therapy.

## SESSION 2. DRINKING WATER PRODUCTION

### 2.1 Upgrade of Conventional Water Treatment Plants with Ozone to Reduce Formation of Chlorinated Disinfection Byproducts

M. ONEBY, J.H. BORCHARDT, R. LIN (USA)

A California water agency (Agency) integrated an ozone disinfection process into an existing conventional treatment train that produces potable water for several communities in Southern California. In the potable water treatment plant upgrade, ozone replaced chlorine gas as the primary disinfectant. Intermediate ozone was selected, followed by biologically-active carbon filters. A comparison of 8 years of disinfection byproduct data; 5½ years prior to ozone and 2½ years after, indicates a 37% to 71% drop in TTHM formation amongst four existing sample sites in the distribution system. The new process treatment train has enabled the water agency to meet regulated disinfection byproduct limits for regulated trihalomethane (THM) and haloacetic acid (HAA) compounds at all sample locations in the respective distribution systems as required by the Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBP Rule).

### 2.2 Ozone automation challenges and solutions

K.L. RAKNESS (USA)

Ozone applications achieve many different water and wastewater treatment objectives, including disinfection and oxidation of targeted inorganic and organic compounds. Performance is monitored by laboratory testing of grab samples, such as MIB, Geosmin and hydrogen sulfide. Performance objectives from calculations include disinfection "CT" and virus or *Giardia* log inactivation. Continuous, on-line measurements are used for minute-by-minute control, including ozone residual, oxidation-reduction-potential (ORP), ultraviolet light transmittance (UVT) and disinfection log inactivation.

Constant ozone concentration (CC) control logic is the industry-default automation strategy. Gas flow and generator power are adjusted to achieve set-point ozone dose at set-point ozone concentration. Automatic CC control performs well during steady-state operation, which is defined as non-varying water flow and unchanging operation of ozone generators and concentration meters. However, significant challenges exist during non-steady state operating conditions, including reduction in applied ozone dose for several minutes that results in regulatory non-compliance. To avoid this situation, plant operators intervene and switch to manual control until steady-state operation resumes. This paper will discuss field-examples where treatment performance has been negatively affected by CC control logic. Potential solutions are discussed to achieve more complete or "robust" control during non-steady-state operating conditions.

### 2.3 Bromate formation mitigation in an Australian water high in bromide

C. JAKUBOWSKI, C. CONWAY (Australia)

A laboratory testing programme was developed to examine bromate mitigation during ozonation of surface waters high in bromide from Queensland, Australia. Monitoring of these waters identified bromide ranging between 300 µg/L to 1000 µg/L, and a high potential for the formation of bromate at levels exceeding the Australian Drinking Water Guideline limit of 20 µg/L. In the testing, samples were dosed with 2.5 mg/L of ozone and contacted for 30 minutes prior to quenching with dry nitrogen. Mitigation measures examined included pH depression, ammonia dosing, chlorine dosing and combinations of each of these approaches.

Cedar Grove Weir raw water tested had a bromide concentration of 430 µg/L and a dissolved organic carbon (DOC) concentration of 4.7 mg/L. Powdered activated carbon (PAC) dosing, lime softening and coagulation reduced DOC to 3.3 mg/L and 2 mg/L for ozonation testing. The combination of pH reduction (ozonation at pH 6.5) and ammonia and chlorine dosing was found to limit bromate formation to 10 µg/L for this water. pH reduction alone had a considerable effect on bromate mitigation, with ozonation at pH 6.5 producing only 44% of the bromate formed at pH 7.5 for the 2 mg/L DOC sample. Ammonia addition at pH 6.5 further reduced bromate, producing only 12% of the bromate formed at pH 7.5. Chlorine addition prior to ammonia dosing and ozonation had only a negligible effect on bromate formation, however in practice the ozone demand and required ozone dose to achieve target ozone residuals could be reduced which would in turn reduce bromate generation. The mitigation of ozonation bromate formation observed at these levels is promising for bromide concentrations of the magnitude experienced.

### 2.4 Innovative integrated approach based on differential metabolomic profiling and estrogenic activity testing to reveal and identify biologically active by-products of estrone-sulfate after ozonation of drinking water

M. BOURGIN, G. GERVAIS, E. BICHON, J.P. ANTIGNAC, F. MONTEAU, G. LEROY, L. BARRITAUD, M. CHACHIGNON, V. INGRAND, P. ROCHE, B. LE BIZEC (France)

For a few years, the concern of water treatment companies is not only focused on the removal of micropollutants but has been extended to the study of the potential biologically active by-products. Therefore, some methods dedicated to the detection and structural characterization of by-products have emerged for evaluating the efficiency of the water treatment processes. However, most of these studies are usually carried out under simplified conditions (e.g. high concentration of micropollutants and disinfection agent, use of deionized or ultrapure water as media or buffering of solutions) and somewhat unrealistic conditions compared to that implemented in water treatment plants. In the present study, a real water sample was fortified at the part-per-billion level (50 µg L<sup>-1</sup>) with estrone-3-sulfate (E1-3S) before being ozonated (at 1 mg L<sup>-1</sup>) for 10 min. In a first step, targeted measurements evidenced a degradation of the parent compound (> 80 %) in 10 min. Secondly, a non-targeted profiling approach derived from metabolomic allowed to reveal 11 ozonation by-products, among which 4 were found predominant. The estrogenic activity of these water samples spiked with E1-3S before and after treatment was assessed by the ER-CALUX assay and was found to decrease significantly after 10 min of ozonation. Finally, this innovative methodological strategy demonstrated its suitability and relevancy for revealing unknown compounds generated from water treatment, and permitted to generate new results regarding specifically the impact of ozonation on estrone-3-sulfate. These results confirm that ozonation is effective at removing E1-3S in drinking water and indicate that the by-products generated have significantly lower estrogenic activity.

### 2.5 Application of oxidation processes for membrane fouling control in seawater

Y. PENRU, S. ESPLUGAS, S. BAIG (Spain, France)

Seawater desalination by reverse osmosis is one of the solutions to provide ample and safe drinking water without impairing natural freshwater ecosystems. Nevertheless, membrane processes suffer a major drawback: the phenomenon of membrane fouling. This work aims to evaluate the performances of two oxidation processes namely ozonation and (UV/H<sub>2</sub>O<sub>2</sub>) for membrane fouling removal in seawater. For this, several parameters were monitored, organic matter degradation, disinfection performances, a most of all standardized fouling measurement. Both processes achieved seawater disinfection and organic matter degradation but low mineralization (<10%). These results explained the lower resistance of filtration cake formed during ultrafiltration test. Moreover, higher was the oxidant dose, better was the seawater filtration.

### 2.6 Ozone disinfection efficiency of resistant microorganisms assessed at a drinking water treatment plant by combining inactivation kinetics and computational fluid dynamics

P. TALBOT, L. MARTINELLI, S. TALVY, E. CHAUVEHEID, B. HAUT (Belgium)

In this work, a method to assess the efficiency of a drinking water plant to inactivate resistant microorganisms using ozone is proposed. This method compares the duration of the lag phase of the ozone inactivation of resistant microorganisms with the contact time distribution of these microorganisms with the disinfectant in the plant. To evaluate the duration of the lag phase, an experimental procedure is proposed and applied to

*Bacillus subtilis* spores. These spores are used as a surrogate for resistant microorganisms such as *Cryptosporidium parvum* oocysts. The procedure aims at characterizing the ozone inactivation kinetics of *Bacillus subtilis* spores for different temperature and ozone concentration conditions. From experimental data, the duration of the lag phase of the ozone inactivation of *Bacillus subtilis* spores is identified for different temperature and ozone concentration conditions. To evaluate the contact time distribution between microorganisms and ozone in a disinfection step of a drinking water plant, a computational fluid dynamics tool is used. The proposed method is applied to an existing drinking water plant located in Belgium and operated by Vivaqua. This plant uses the ozone as disinfectant. Results show that the durations of the lag phase and contact times are both in the same order of magnitude of a few minutes. For a large range of temperatures and ozone concentrations in the plant ozonation channel and for the highest hydraulic flow rate applied, a significant proportion of resistant microorganisms similar to *Bacillus subtilis* spores is not inactivated.

### SESSION 3. AGRI-FOOD APPLICATIONS (Cont'd)

#### 3.1 Effect of ozone treatment on microorganisms viability evaluated by flow cytometry and plate count technique

E. SARRON, T. AUSSENAC, N. COCHET, P. GADONNA-WIDEHEM (France)

The effectiveness of ozone in the decontamination of microorganism suspensions was evaluated by two methods: flow cytometry and plate count technique. Two conventional fecal indicators *Escherichia coli* and *Enterococcus faecalis*; one foodborne pathogen *Listeria monocytogenes* and a pectinolytic bacterium *Pectobacterium carotovorum* were tested. Ozone treatment was very effective in reducing the bacteria populations and was characterized by using Ct and D-values. At the beginning of treatments, the D-values were higher for Gram positive compared to Gram negative bacteria. When the ozone treatment was prolonged, bacterial destruction was strain-related rather than Gram-related. The role of ozone on membrane damage and bacterial destruction was studied by flow cytometry analyses: Propidium iodide staining revealed that ozone treatment altered bacterial membranes before causing bacterial death. Flow cytometry was shown to be an efficient tool for revealing bacterial physiological state.

#### 3.2 Catechin in tea seed oil from *Camellia oleifera* Abel

J. SINGKHORAT, N. SUEALEK (Thailand)

A high performance liquid chromatographic (HPLC) method was developed and validated for quantitative determination of polyphenols (catechin) in extracts of *Camellia oleifera* Abel. The analysis was carried out on ACE-HPLC Column (C<sub>18</sub> with 150 × 4.6 mm) using methanol-water containing 2% acetic acid (11:89 v/v) as mobile phase under isocratic system. The flow rate was 1.0 ml/min and the detection was at 280 nm. The validation using catechin as standard demonstrated that the method presented linearity (linear correlation coefficient = 0.999), precision (relative standard deviation <4%) in the concentration range 25.525-102.1 µg/mL with gallic acid as internal standard. The limit of detection (LOD) was 1.061 µg/mL and the limit of quantification was 3.54 µg/mL. This method allowed the identification of catechin in the ethyl acetate extracts obtained from the commercial tea oil. The average concentrations of (+)-Catechin in the commercial tea seed oil was 5.0899 µg/mL. Results obtained in this study will serve as quality control and useful reference for supplement development and pharmaceutical industry.

#### 3.3 Disinfection of plastic pockets for food packaging with ozonated water

Yann CHEVELU (France)

The study concerns the decrease of the load situated on surface by plastic pockets of cooking in aerobic mesophile Flora (FAM) and in Entérobactéria (Enterobacteriaceae).

#### 3.4 Disinfection of atmosphere and surfaces with some gaseous ozone

Yann CHEVELU (France)

The study concerns the decrease of the load in listeria and yeasts / molds situated in atmosphere and surface in food-processing industry.

#### 3.5 Decontamination of treated wheat seeds by ozonation

L.V. HOANG, C. COSTE, T. AUSSENAC (France)

Because of its exceptional oxidizing power, ozone has been used for years in numerous application areas. In the present study, experiments have been realized to evaluate the influence of operational conditions (pre-humidification rate, inlet ozone concentration and reaction time) on the degradation of the most frequently used pesticides for the treatment of wheat seed. These experiments were designed and conducted according to a factorial Box-Behnken design. The large majority of the pesticides studied (prothioconazol, thiram, teffuthrin and fludioxonil) are very rapidly eliminated by ozonation. Whatever the experimental conditions used, ozonation causes, indeed, a total elimination (i.e. below the analytical limits of detection) of these molecules. Imidacloprid which is, in our experimental conditions, the only compound which presents some resistance to ozonation, was chosen to modelize the effects of the different variables on the decontamination process. A model, generated from a second order multiple regression equation, has been proposed to predict the degradation of Imidacloprid by ozonation. This highlights the importance of the pre-humidification rate and the reaction time compared to the inlet ozone concentration. These experiments which have been extended to other species (maize and canola) and other pesticides have allowed us to file a new patent.

#### 3.6 Investigation of the potential use of ozone as an alternative to chemical treatment of medicated straw

P.J. SOLAN, V. VALDRAMIDIS, C. ANDRONY, B.K. TIWARI, C. O'DONNELL, G. OWENS, A. G.M. SCANNELL, T.P. CURRAN (Ireland, France, UK)

Animal bedding material is considered a rich source of bacteria and fungi. Contaminants range from (mycelia) yeasts to filamentous fungi species such as *Aspergillus*, *Fusarium*, *Alternaria*, *Cladosporium*, *Epicoccum*, *Penicillium*, *Verticillium* and *Enterobacteria*. Previous bacteriological findings have reported that animal disease outbreaks are associated with the quality of the animal environment. Propionic acid and formaldehyde are widely accepted forms of cleaning agents; however they do not come without drawbacks, residues being one of them. This issue could be overcome by the use of ozone which has a very short half life. The objective of this work was to assess ozone gas treatment as a potential alternative to chemicals in the production of medicated bedding straw. Comparisons were made between ozone and chemically treated straw material. Microbial analysis was carried out on a number of ozone treatments (flow rates: 0.031, 0.125, 0.5 l/min, concentrations: 36, 99, 150 µg/ml, treatment time: 0, 5, 15, 30 mins, and residual times of 0 to 18 hrs). Results indicated that ozone successfully reduces the microbial counts and the fungi levels by more than 1.5 logs (cfu/g) proving the potential use of ozone gas as an alternative greener technology to chemical treatments.

#### 3.7 Total unsaturation (TU) as control method for ozone's reaction with vegetable oils

J. P. GUERRA BLANCO, T. POZNYAK, I. CHAIREZ, I. CORDOVA R. (Mexico)

In this work the ozonation of four vegetable oils (grape seed, sunflower, olive and avocado) with different unsaturation degree (total >C=C<) was studied. TU is a potent technique to quantify the oxidizable substrate by ozone, by measuring the ozone necessary to reach the complete sample's oxidation, then, it can be used as control method for ozone's reaction with vegetable oils. Oils were characterized by measuring its total unsaturation (TU) at the beginning; TU was different for each oils. This result depends on their fatty acids composition. During ozonation, the >C=C< decrease as

well as the ozonides formation dynamics were measured (TU and FT-IR). Their behaviors have good correspondence (inversely) and both dynamics were similar for all oils. However, ozonation periods were different. These periods were determined until the complete >C=C< decomposition was reached and the corresponding ozonides formation was maximum.

## SESSION 4. TREATMENT OF INDUSTRIAL WASTEWATERS

### 4.1 Decomposition of toxic organics in waste water of the pulp and paper industry by ozonation and biodegradation

*J. AMACOSTA CASTILLO, T. POZNYAK, S. SILES ALVARADO (Mexico)*

In the present work the degradation of toxic organics in the pulp and paper mill effluent from the bleaching step from the Kraft process was studied. The purpose of this study was to degrade the toxic organics by the combination of ozonation and biodegradation, because these are recalcitrant and resistant to the bio-treatment by the activated sludge. The treatment of this wastewater was carried out by ozone during 60 minutes in a semi batch reactor and finally with the acclimated bacterial consortium. The ozonated samples were analyzed by a Spectrophotometry UV-Vis with the absorbance in a wavelength of 190 to 300nm and by High Performance Liquid Chromatography to study the behavior of the degradation dynamics, discoloration and monitoring of the by-products formation during the reaction as well as the elimination of their with the microorganisms.

### 4.2 Treatment of bio-recalcitrant wastewater by coupling ozone and activated carbon

*T. MERLE, M.H. MANERO, J.S. PIC, H. DEBELLEFONTAINE (France, Saudi Arabia)*

The coupling of activated carbon adsorption and ozone oxidation (AC/OZ) appears to be an interesting process to increase the formation of hydroxyl radical. Accordingly, this study was focused on the interaction between ozone and three different activated carbons (2 microporous and 1 mesoporous) in order to improve the removal of bio-recalcitrant molecules in a combined process. The focused molecules were 2,4-dichlorophenol (2,4-DCP) and nitrobenzene (NB), a real industrial wastewater was also studied. The addition of 10 g.L<sup>-1</sup> activated carbon increased ozone decomposition. The decomposition rate could be multiplied by 15 with the mesoporous activated carbon. However the structure of this solid was strongly damaged under ozone attack and the ozone decomposition has been decreasing with experimental runs. The two microporous adsorbents showed stable structure properties under ozone attack and interesting basic properties to enhance the ozone decomposition rate. Comparisons were made between single ozonation and the combined process. Higher efficiencies were found for NB removal with AC/OZ whereas no differences were pointed out for 2,4-DCP oxidation and a negligible improvement was noted for real wastewater treatment.

AC/OZ showed greater interest when it was used in sequential mode. The regeneration of activated carbon could be better controlled: in this study the adsorption capacity of the activated carbon was increased up to 2.7 times using 2,4-DCP and up to 1.7 times when loaded with organics coming from industrial wastewater.

### 4.3 Oxidative regeneration of toluene saturated natural zeolite by gaseous ozone: effect of zeolite chemical surface characteristics

*S. ALEJANDRO, H. VALDÉS, M.H. MANÉRO, C.A. ZAROR (Chile, France)*

In this study, the effect of zeolite chemical surface characteristics in oxidative regeneration of toluene-saturated samples was investigated. Three modified zeolite samples were prepared from a natural Chilean zeolite (53% clinoptilolite, 40% mordenite and 7% quartz) in order to generate different surface characteristics. Natural and modified zeolite samples were characterized by nitrogen adsorption at 77 K, X-ray fluorescence (XRF), helium pycnometry technique, Fourier transform infrared spectroscopy (FTIR) and High Performance Liquid Chromatography (HPLC). Chemical modifications of natural zeolite showed the role of surface acid sites on regeneration of exhausted zeolites. The presence of oxidation by-products has a negative influence on zeolite adsorption capacity recovery.

### 4.4 Regeneration of coked zeolite by ozonation

*S. KHANGKHAM, C. JULCOUR, S. DAMRONGLERD, C. NGAMCHARUSSRIVICHAI, M.H. MANÉRO, H. DELMAS (France, Thailand)*

Regeneration of coked ZSM-5 zeolite was performed by oxidation with ozone at low temperature range (< 150°C) so that to restore catalytic activity. Physicochemical properties of the samples were characterized by several techniques: thermogravimetry, elemental analysis (carbon content), porosimetry and pyridine adsorption (acidity). Experiments were carried out at various reaction temperatures, gas hourly space velocities and inlet concentrations of ozone. They show that partially coked samples (containing 3% wt. of C) can be successfully regenerated by ozone with carbon removal up to 80%. Carbon removal is improved by increasing the inlet ozone concentration in the range 16 to 50 g/m<sup>3</sup>, with almost linear trend, and by increasing time on stream despite the conversion seems to plateau after 2 h. Coke oxidation with O<sub>3</sub> starts at low temperature and exhibits an optimum at about 100°C. For higher temperatures, the rate of ozone decomposition becomes much faster than its diffusion rate, that must make radical species unavailable for the coke deposit within the particles and lowers the overall oxidation yield. Indeed, catalytic decomposition of ozone is found to occur significantly above 100°C: if less than 10% of ozone is thermally decomposed at 100°C by passing through the empty heated tube reactor, O<sub>3</sub> decomposition reaches 90% when the reactor is filled with fresh ZSM-5 catalyst. Thus regeneration of coked zeolite particles involves both complex chemical reactions (coke oxidation and O<sub>3</sub> decomposition to active but instable species) and transport processes (pore diffusion to the internal coked surface).

## SESSION 5. POSTER SESSION

### 5.1 Photodegradation and photooxidation of phenylarsonic acid in aquatic solution

*M. CZAPLIKA, Ł. BRATEK, K. JAWOREK (Poland)*

The paper presents results of the studies photodegradation and photooxidation of phenylarsonic acid (PAA) in aquatic solution. The water solution which consist of 2.7 g/l phenylarsonic acid was subjected to AOP process in UV, UV/H<sub>2</sub>O<sub>2</sub> and UV/O<sub>3</sub> systems. Photodegradation by using wavelength 180 nm led to removal 59 % of PAA during 4 hours. In solution after process phenol, acetophenone, o-hydroxybiphenyl, benzoic acid ethyl ester and 2-dibenzofuranol were identified by using GC/MS method. In UV process solid phase precipitates was observed. In the cases of photooxidation by O<sub>3</sub> and H<sub>2</sub>O<sub>2</sub> phenylarsonic acid was degraded on level 92 % and 100 %, respectively. In solution after photooxidation by H<sub>2</sub>O<sub>2</sub> phenol, phthalic anhydride, 2,3-diphenylmaleic anhydride, benzophenon and benzoic acid methyl ester were identified. For these processes precipitation weren't observed.

### 5.2 Kinetic study of the process Ad / Ox to the removal of phenol using different operational variables

*I. ALEGRÍA, J.I. LOMBRAÑA, F. VARONA, A. MENDILIBAR, S. SALVADOR, J. SANZ (Spain)*

Industrial wastewaters, especially in the chemical industry, cause major environmental problems due to its high toxicity. Conventional treatment systems are insufficient to destroy these toxic organic pollutants, thus it is necessary to develop new processes to treat these effluents prior to discharge to surface waters. Among the alternatives proposed are adsorption on active carbon and oxidation of pollutants by ozonation. Recently some progress has been made in wastewater treatment combining these two techniques sequentially or jointly.

In this paper a simulation in the process of removing phenol by ozonation in the presence of activated carbon has been made. A continuous plug

flow reactor has been used consisting in a column of 20 mm inner diameter and a 400 mm high bed of activated charcoal (10 g). As a result some oxidation kinetic constants have been calculated, in accordance with a prior calculation of the diffusion parameters, to have a suitable definition of the process global kinetic performance.

### 5.3 Petrochemical effluents treatment via advanced oxidation process: zeolites reactivity toward ozone and 2,4-dimethylphenol

*W. ABOUSSAOU, M.H. MANERO, J.S. PIC, H. DEBELLEFONTAINE (France)*

The petrochemical industry generates wastewaters containing non-biodegradable pollutants like phenolic compounds which must be treated by specific processes. This study aims to develop, for these effluents, an efficient and reliable advanced oxidation process that combines adsorption on zeolites and catalytic ozonation. 2,4-dimethylphenol (DMP) is chosen as a paradigm molecule and three commercial zeolites are tested; a Faujasite-Y, a Mordeite and a Silicalite. Adsorption kinetics was studied and very low rates were found with zeolites in pellets, but a noticeable increase of these rates was found when the zeolites are ground to powder, evidencing the importance of mass transfer limitation. The single ozonation of DMP showed a rapid degradation kinetics, but limited by ozone transfer from the gas to the liquid phase and the enhancement factor E could be estimated. During catalytic ozonation, and despite their interesting adsorption properties, zeolites showed no increase in the overall DMP degradation rate, except for Mordeite, for which DMP overall degradation time is shortened by about 30%. The alumina binder used for Mordeite might have a catalytic effect by increasing the concentration of Bronsted acidic sites and, consequently, might accelerate degradation kinetics by contributing in ozone decomposition to hydroxyl radicals.

### 5.4 Advanced oxidation process in hospital wastewater treatment

*K. GONZALEZ LABRADA, I. QUESADA PEÑATE, U. JAUREGUI HAZA, C. JULCOUR, C. ANDRIANTSIFERANA, M.H. MANÉRO, C. MARTIN, H. BUDZINSKI, E. GENESTE, C. ALBASI (France, Cuba)*

The degradation of selected pharmaceuticals in osmotic water and hospital effluent from a membrane bioreactor is studied using photo-Fenton process. The selected pharmaceuticals are two anticancerous molecules, cyclophosphamide and isophosphamide, and one antibiotic, ciprofloxacin. Several concentrations of  $Fe^{2+}$  ( $FeSO_4 \cdot 7H_2O$ ) and  $H_2O_2$  are used following factorial design plan  $3^2$ . The results show a fast degradation of the studied molecules, of more than 75 % after 15 minutes.

### 5.5 Computer Simulation of Advanced Oxidation Processes by Ozone and Hydrogen Peroxide

*A. IGNAJEV, A. PRYAKHIN, V. LUNIN (Russia)*

A mechanism for ozone decay in water solutions was proposed. Kinetics of aqueous ozone decomposition in presence of hydrogen peroxide was studied using computer simulation. Optimal conditions (concentrations of reagents, pH) for indirect radical ozonation were calculated. It was shown that an excess of hydrogen peroxide suppresses radical formation and inhibits radical ozonation pathway.

### 5.6 Effect of soil physical properties on the decomposition dynamics of phenanthrene by ozonation

*J. AMACOSTA CASTILLO, J. RODRIGUEZ, T. POZNYAK, A. GARCIA, C. GOMEZ, I. CHAIREZ (Mexico)*

In this paper was studied the effect of the soil physical properties on the decomposition of phenanthrene by ozone in two different porous media (baked sand and agricultural soil). The effective degradation of phenanthrene in both systems was obtained during 30 minutes of ozonation. The contaminant decomposition was more efficient in the burned soil (93%) compared to the baked sand (70%). This difference was linked mainly to the physical properties of the soil such as surface area, porosity, the particle size and natural composition of each porous medium, as well as the distribution of the particles size of phenanthrene formed in the artificial contamination of the environment by the evaporation of the solvent. The last parameter is very difficult to control. The mineral composition of both soils was obtained by x-ray diffraction (XRD); the physical properties such as humidity, porosity, particle density were determined by the specific techniques regulated by ASTM. The variation of the particles size distribution of phenanthrene in soil was studied by the technique of scanning electron microscopy (SEM). Finally, the decomposition dynamics of phenanthrene as well as of the formation and decomposition of byproducts in ozonation were carried out by using of UV-Vis spectrophotometry and high pressure liquid chromatography (HPLC).

## SESSION 6. FUNDAMENTAL AND ENGINEERING

### 6.1 Thermally enhanced UV/H<sub>2</sub>O<sub>2</sub> application to a high loaded surfactant effluent

*J. SANZ, J.I. LOMBRANA, A. M. DE LUIS (Spain)*

Several studies have examined the effect of reaction temperature in advanced oxidation technologies, with significant improvement in the performance of oxidation applying temperature conditions slightly higher than ambient. The use of reaction temperatures above ambient would be justified as they could represent the thermal conditions in which some polluted effluents are discharged, as is often the case for example of the dyeing industry. The aim of this work is to investigate the feasibility of applying higher reaction temperatures in the UV/H<sub>2</sub>O<sub>2</sub> advanced oxidation process to treat high-loaded surfactant solutions. In this case, oxidation reactions have been carried out on 1 g L<sup>-1</sup> solutions of LAS (linear alkyl benzene sulphonates) at constant reaction temperatures of 25, 40, 60 and 80 °C. This work has focused in the determination of the optimal operating conditions, specially according to the influence of temperature on the input power and on the peroxide dosage. In addition, other aspects related to the performance of the oxidation reaction were investigated, such as the nature of the generated intermediates, the biodegradability of the treated samples or the extent of the mineralization (full degradation). Finally, it has also been considered of interest the analysis of possible beneficial effect of temperature on the main kinetic parameters, thus: activation energies and the photolytic quantum yield.

### 6.2 Screening of new catalysts for the development of advanced oxidation process combining ozone and zeolites or mesoporous materials

*J. VITTENET, J. MENDRET, S. BROSILLON, A. GALARNEAU (France)*

Zeolites are aluminosilicate materials and have been used to improve ozonation processes. However in literature there is a lack of comprehension of such phenomena. We propose here to perform a screening with different zeolites and aluminosilicate materials to understand the role of such materials (catalysts and/or adsorbents). Zeolites such as sodalite (SOD), zeolite A (LTA) and faujasite X (FAU-X) have been synthesized. X-Ray Diffraction (XRD) pattern confirm the crystallinity of the resulting materials and Scanning Electron Microscopy (SEM) images reveal the morphology of the particles. SOD, LTA and FAU feature pore sizes of 0.28, 0.41 and 0.78 nm, respectively. A mesoporous aluminosilicate Al-MCM-41 (Si/Al=15) featuring larger pore diameter of 3.8 nm was synthesized to investigate the effect of pores size on the decomposition of target pollutants. The degradation of two pollutants 2,4-dimethylphenol (2,4-DMP) (50 ppm) and phenanthrene (PHE) (0.25 ppm) will be followed within time using ozone combined to these different materials in aqueous media. Adsorption tests (without ozone) were performed prior ozonation to estimate the adsorption capacity of the materials. These experiments were conducted under the same conditions as ozonation tests (25°C, pH 5, stirring at 150 rpm). The evolution of the pollutant concentrations was followed by High Performance Liquid Chromatography equipped with an UV or fluorimetric detector (HPLC-UV/Fluo). Equilibrium times for adsorption in FAU-X were reached within 2 and 6 h for PHE and 2,4-DMP, respectively. No adsorption was observed with SOD and LTA zeolites. Ozonation experiments will be performed with an ozone gas flow of 30 L/h, an ozone concentration of 5 g/Nm<sup>3</sup> in a 2 L glass reactor with 1 g/L of material.

### 6.3 Phenol oxidation in a semi industrial ozone pilot plant: the effects of some operating parameters

V. ACHA, L.V. HOANG, A. BAK, R. MARION, O. POURRET (France)

Phenol solutions at 25, 50 and 100 mg/L were totally eliminated in a 500 L-semi-industrial Advanced Oxidation Process (AOP) process. A good relationship was established between the ozone concentration in the off-gas, phenol and their oxidation by-products (1,2-dihydrobenzen, 1,4-dihydrobenzen and 1,4-dihydroquinone). To guarantee a good COD removal, the 5 m-high reactor column was equipped with a closed loop circulation system which allowed to increase the retention time and to optimize the ozone transfer in the pilot. Conditions favouring the ozone direct reaction or the indirect reaction at alkaline pH did not affect or slightly affected the phenol degradation. For complete phenol removal the optimum input levels of ozone concentration were found to be in the range of 70 g/m<sup>3</sup> NTP to 110 g/m<sup>3</sup> NTP.

### 6.4 Comparative analysis of the effect of pH on adsorption process of ozonation (Ad/Ox) for the removal of phenol

I. ALEGRÍA, J.I. LOMBRANA, F. VARONA, J. SILVA, J. SANZ (Spain)

Industrial wastewaters, especially in the chemical industry, cause major environmental problems due to its high toxicity. Conventional treatment systems are insufficient to destroy these toxic organic pollutants, thus it is necessary to develop new processes to treat these effluents prior to discharge to surface waters. Among the alternatives proposed are adsorption on active carbon and oxidation of pollutants by ozonation. Recently some progress has been made in wastewater treatment combining these two techniques sequentially or jointly.

In this paper the effect of the reaction pH in the process of removing phenol by ozonation in the presence of activated carbon has been studied. A continuous plug flow reactor has been used consisting in a column of 20 mm inner diameter and a 400 mm high bed of activated charcoal (10 g).

As a result it can be concluded that the effect of basic pH value, especially the use of buffered solutions, is recommended for high phenol solutions (1000 mg L<sup>-1</sup>). Acid pH values are suitable for 500 and 250 mg L<sup>-1</sup> concentrations. In these cases phenol oxidation increases as the pH becomes acidic, being the optimum pH values pH=9 for 500 mg L<sup>-1</sup> of phenol and pH= 3 in the case of 250 mg L<sup>-1</sup>.

### 6.5 Catalytic ozonation of benzoic, phthalic and 2,4-dichlorophenoxyacetic acids in water: Effect of NiO concentration

D. MAGALLANES, J.L. RODRÍGUEZ, T. POZNYAK (Mexico)

In this work, the effect of chemical structure of three aromatic compounds, phthalic, benzoic and 2,4-dichlorophenoxyacetic (2,4-D) acids were studied in the catalytic ozonation in presence of NiO. Diverse catalytic properties (acid-base character, morphology and crystallite phases) had been investigated by several researches in the ozonation of organic pollutants in water. Nevertheless, the chemical structure of model compound also was important because the catalytic ozonation with metal oxides can be favored to the formation metal – organic complexes. The similar characteristics of choice compounds were the presence of the benzene ring and carboxyl groups, while the difference were the number of substituted carboxyl group and one had chlorines (2,4-D). So that, the effect of chemical structure of compounds was studied in the catalytic ozonation varying the nickel oxide concentration in water (up 0.1 to 1.0 g L<sup>-1</sup>) that is very important for the heterogeneous system (ozone-water-metal oxide). In general, the 2,4-D degradation increases with the increment of the catalyst amount, and the optimal concentration of catalyst was of 0.4 g L<sup>-1</sup>. This seems reasonable, because the increase of the catalyst concentration can enhance the formation of ·OH that favors to the 2,4-D elimination. Nevertheless, phthalic and benzoic acids did not show similar behavior, because the acid chemical structure influences on the catalytic ozonation dynamics.

## SESSION 7. MICROPOLLUTANT REMOVAL IN URBAN WASTEWATERS

### 7.1 Removal of micro pollutants from municipal waste water – already "State of the art"? (A review on Europe's activities)

J. MIELCKE, A. RIED (Germany)

Oxidation, and here predominantly the application of ozone, has been studied widely for the removal of persistent substances (POPs) from waste water. In Europe, mainly in Switzerland, Austria, Germany, the Netherlands and the UK several studies and even joint research projects have been conducted. Currently, 3 demonstration plants in North Rhine Westphalia/Germany have started operations. New, continuative research projects have been started as well to gain missing knowledge concerning the potential optimization of tertiary oxidation treatment, risks from potential by-products; integration into existing WWTP; long term experiences and advanced cost calculations.

### 7.2 Microcontaminant removal from municipal secondary effluents by ozonation

R.F. DANTAS, A. CRUZ, B. BAYARI, C. SANS, S. ESPLUGAS (Spain)

The aim of this work is to study the effect of the ozonation on the removal of microcontaminants in secondary effluents. In this study, the atrazine was elected to represent the class of the microcontaminants due to it is included in the European list of priority contaminants. Effluent samples were taken at the output of the secondary clarifier from the municipal wastewater treatment plant in Barcelona, Spain. To perform the experiments, an atrazine (C<sub>8</sub>H<sub>14</sub>ClN<sub>3</sub>) concentrated solution was spiked in the samples in order to achieve the desired initial concentration (0.1 mg L<sup>-1</sup>). The experiments were carried out in a laboratory-scale ozone device, using a 2-L glass reactor. The treatment with low doses of ozone could reduce atrazine concentration from 0.1 mg L<sup>-1</sup> to 0.01 mg L<sup>-1</sup> in 60 min, with a transfer of 26.7 mg of O<sub>3</sub> per liter of treated sample. The treatment produces organic matter oxidation and turbidity removal; however it is not able to produce mineralization at the applied conditions.

### 7.3 Evaluation of advanced oxidation processes for the reduction of refractory micropollutants in treated wastewater

S. BESNAULT, S. MARTIN RUEL, S. BAIG, B. HEINIGER, M. ESPERANZA, H. BUDZINSKI, C. MIÈGE, M. COQUERY (France, Switzerland)

Conventional wastewater treatment processes can eliminate part of the micropollutants entering the plant. However, some "refractory" micropollutants remain in treated wastewater at the outlet of the plants. Tertiary treatments can be implemented in order to reduce the concentrations of micropollutants in treated wastewater. The objective of this study was to assess the removal of 20 organic micropollutants (pesticides and pharmaceuticals) with ozone alone and different Advanced Oxidation Processes (AOP) based on combinations of ozone (O<sub>3</sub>), hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and UV with a pilot unit installed in two different urban wastewater treatment plants as polishing stage. Secondary treatments consisted in a membrane bioreactor (MBR) and a conventional activated sludge (CAS) followed by a sand filter. Dissolved organic carbon (DOC) and micropollutants concentrations were lower after membrane bioreactor than after conventional activated sludge with sand filter. Similar combinations were tested at the two plants and results were repeated. Under the test conditions:

- The betablockers analysed were eliminated by more than 98% with ozone alone. For these molecules, that are very reactive towards ozone, a radical oxidation pathway promoted by AOP did not improve the removal yield.
- The antibiotics analysed were not completely removed by ozone. The addition of H<sub>2</sub>O<sub>2</sub> to O<sub>3</sub> increased the removal yield by 20% for roxithromycin and erythromycin. In combination with ozone, the increase of UV dose and residence time allowed a better removal of roxithromycin, erythromycin and sulfamethoxazole.
- Ozone alone was not sufficient to remove the pesticides AMPA and atrazine (<70%) that are refractory to molecular ozone. For all the pesticides, an addition of H<sub>2</sub>O<sub>2</sub> to ozone increased the removal yield by 5 to 50%. High removals were also obtained with UV/H<sub>2</sub>O<sub>2</sub>.

## SESSION 8. URBAN WASTEWATER TREATMENT

### 8.1 Advanced treatment of tertiary effluent with ozone

M. ONEBY (USA)

A bench scale study determined the effectiveness of ozone as a disinfectant on unfiltered and filtered secondary effluent from a municipal wastewater treatment plant. The experiments included characterization of the effluent using analysis of standard water quality parameters, determination of ozone demand and decay, and challenge testing of microbial inactivation. Challenge tests were performed on MS2 coliphage. Additionally, background concentrations of somatic virus, heterotrophic plate counts (HPC), fecal coliform, and total coliform on samples before and after ozonation provided an estimation of log removal for different levels of ozonation. Background ozone demand for the secondary effluent was in the range of 5.0 to 8.4 mg/L, with filtered samples always having lower demand than the unfiltered samples. The ozone decay rate was correlated to ozone dose and residual concentration – higher doses and corresponding higher dissolved ozone residuals demonstrated faster ozone decay. Satisfaction of ozone demand is a key factor in meeting log inactivation requirements of microorganism. Tests that satisfied ozone demand exhibited a substantially higher inactivation of the microorganisms studied.

### 8.2 Assessing WWTP effluent organic matter conversion during ozone and UV/H<sub>2</sub>O<sub>2</sub> treatment using multiple surrogates

W.T.M. AUDENAERT, D. VANDIERENDONCK, S.W.H. VAN HULLE, I. NOPENS (Belgium)

In this study, municipal wastewater treatment plant effluent was tertiary treated using single ozonation or UV/hydrogen peroxide advanced oxidation. Hydroxyl radical production rates and effluent organic matter (EfOM) conversions in terms of biodegradability, molecular weight, polarity and UV-absorbance were measured and compared. Ozone was found to produce significant amounts of hydroxyl radicals of which the concentration increased as function time. During the UV/H<sub>2</sub>O<sub>2</sub> process, the hydroxyl radical concentration was more or less constant, provided that H<sub>2</sub>O<sub>2</sub> was not limiting. Both processes showed similar trends with respect to conversion of effluent organic matter: biodegradability enhancement, cleavage of aromatic rings and double bonds and production of smaller, more oxygen rich compounds. The hydrophobic acid fraction represented 70% of the EfOM and decreased drastically after oxidation.

### 8.3 Benefits of ozonation as pretreatment of membrane filtration

B. DOMENJOU, S. ESPLUGAS VIDAL, S. BAIG (Spain, France)

The changes in filtration mechanisms and in fouling potential induced by ozone application upstream and downstream a microfiltration treatment of a tertiary wastewater treatment plant were assessed. The results show that ozone greatly reduces the potential of the effluents in terms of cake formation at the ultrafiltration membrane surface by both reducing the contents in suspended solids and in biopolymers. The dominant fouling mechanism that controls the flow decline during ultrafiltration tests shifts progressively from a mainly a cake filtration mechanism to a standard blocking mechanism. The results are consistent with the ozone chemistry which indicates that ozone breaks down higher molecular weight molecules, which are prone to deposit on the membrane surface, into smaller molecules. Application of ozone downstream the microfiltration treatment was shown to be much more effective in terms of control of pore blocking and cake filtration phenomena; in this case, oxidation of dissolved foulant substances is not anymore limited by the simultaneous oxidation of particulate organic matter previously eliminated by the microfiltration. Ozone appears to be a good candidate as reverse osmosis pretreatment.

### 8.4 UV and UV/Chlorine Advanced Oxidation Processes for food safety

R. VAN ESCH, K. ANDRE, C. SICHEL (Netherlands, Germany)

The UV/chlorine (UV/HOCl) Advanced Oxidation Processes (AOPs) was assessed for the removal of emerging contaminants (ECs). Energetic and economical comparisons will be presented regarding state of the art technologies UV/H<sub>2</sub>O<sub>2</sub>, AOP, Ozone, Activated Carbon.

The UV/chlorine AOP showed high energy saving potential for the degradation of ECs. Up to 75% energy reduction was achieved for the removal of carbamazepine compared to the state of the art UV/H<sub>2</sub>O<sub>2</sub> AOP. The combination of energy saving compared to existing UV/AOPs and low capital costs compared to ozone oxidation technologies, the overall cost saving for the AOP customer is expected to be between 30%-50% depending on the total treatment volume.

The presented experiments were performed at technical scale (continuous flow reactor). The following ECs have been successfully degraded by the UV/HOCl AOP: desethylatrazine, sulfamethoxazole, carbamazepine, diclofenac, benzotriazole, tolyltriazole, iopamidole and 17 $\alpha$ -ethinyloestradiol (EE2). Initial compound concentrations were 1  $\mu$ g/L (except for the hormones: 0.1  $\mu$ g/L). The water matrixes were tap water and matrixes with increased organic load (46 mg/L DOC). UV/chlorine AOP organic by-product forming potential was assessed for trihalomethanes (THMs). THM by product concentrations remained below 5 ppb. Existing limits for drinking water allow 50 ppb (Germany) / 80 ppb (USA).

## SESSION 9. SLUDGE MANAGEMENT

### 9.1 Full-scale ozonation to reduce filamentous sludge at Klagshamn WWTP

F. NILSSON, K. JÖNSSON, J. DIMITROVA (Sweden)

The feasibility of applying ozone to the return sludge flow of Klagshamn WWTP's two treatment lines in order to reduce the impact of the filamentous bacteria, mainly *Microthrix parvicells* on the settling properties was investigated. A full-scale ozone reaction system was operated and monitored for more than six months. Ozonation improved the settling properties of both lines while at the same time no adverse effect on the nitrification could be seen.

### 9.2 Ozonation Impacts on Waste Activated Sludge

P. KIANMEHR, W. PARKER, P. SETO (Canada, UAE)

Ozonation for pre-treatment of waste activated sludges (WAS) prior to digestion is of growing interest to wastewater treatment utilities. The interest has been formed based upon researches and practices revealing that ozonation reduces the mass of biosolids remaining after digestion and increases the generation of methane as a biofuel. The generated sludge found to be more stable, less odorous and less hazardous due to its lower pathogen content. While there has been considerable study of pre-treatment processes, a common approach to describing the impact of ozonation on sludge biodegradability has not been developed. In addition there has been little evaluation of the interaction between WAS characteristics and ozonation efficiency. In this study, a range of physical, chemical and biological responses were evaluated to assess the impact of ozonation (as a model of chemical pre-treatment processes) on WAS properties as well as sludge digestibility. WAS that was generated at differing SRTs from municipal wastewater was employed to facilitate an assessment of the interaction between pre-treatment and WAS properties on digestibility. The overall objective was to develop protocols that can be employed to characterize the impact of ozonation processes on WAS digestion. These protocols could substantially reduce the costs associated with testing that is required to evaluate pretreatment technologies at wastewater treatment plants.

## CLOSING

Scientific Programme Conclusions  
Special Prize of the Programme Committee  
*M. ROUSTAN*, Chair of the Programmec Committee (France)

Conference conclusion  
*A. RIED*, IOA-EA<sub>3</sub>G President (Germany)

## FOR ANY FURTHER CONTACT

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## SAVE THE NEXT DATES

> IOA-NIG 21<sup>st</sup> Japan Ozone association Annual Conference on ozone Science & Technology  
Hiroshima University, Japan  
June 21-22, 2012  
Information: [takahara-ioa@mrh.biglobe.ne.jp](mailto:takahara-ioa@mrh.biglobe.ne.jp) or [www.i-ozone.org](http://www.i-ozone.org)

> IOA-PAG 2012 Conference Annual Conference & Exposition  
Hyatt Regency Milwaukee, WI, USA  
September 23-26, 2012  
Important date : Deadline for submission of abstracts will be June 6, 2012  
Information: [www.io3a.org](http://www.io3a.org)

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