

The 6th World Congress on Oxidation Catalysis

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The Congress on Oxidation Catalysis has a 20-year-long history. It is held every 4 years and is the most prestigious forum for presentation of research in catalytic oxidation. The latest, 6th Congress took place on July 5–10, 2009, in Lille, one of the most beautiful French cities, which is situated near the France–Belgium border. It is possibly due to the latter circumstance that the Congress had an unusual format. Its organizing committee consisted of French and Belgian parties, which were headed by two cochairmen—Prof. E. Bordes-Richard from the University of Lille (France) and Prof. P. Ruiz from the Catholic University of Leuven (Belgium). The cochairmen shared the numerous duties typical of such great conferences so skillfully that many participants noted the excellent organization of the Congress.

Five invited lectures, 23 keynotes, 116 oral reports, and 327 poster reports were presented in Lille. There were 506 participants, which represented 50 countries.

Here, we will give a brief account of the invited lectures to highlight the areas in which, in the organizers' opinion, the most significant advances deserving general attention have been made in recent years.

The Congress was opened by the lecture entitled "Atomic Aspects of Surface Chemical Reactions," delivered by Prof. K. Asakura, Catalysis Research Center, University of Hokkaido. A great amount of information has been accumulated on the chemistry of surface reactions since the 1960s, when it became possible to grow single crystals and to examine their surface cleaned in an ultrahigh vacuum. However, use of this information in real catalysis involves serious difficulties. One of them arises from incomparable pressures (which vary between 10^{-8} to 10^3 Pa from one study to another). The second stems from the dissimilarity of materials used as catalysts (which can range from a single crystal with a smooth surface to a porous amorphous body). The recent improvements to the existing instrumental methods and the development of new ones have made it possible to circumvent these differences to a considerable extent. This was the main subject of Asakura's lecture.

Prof. F. Cavani, Department of Industrial Chemistry, University of Bologna (Italy), delivered a lecture entitled "Catalytic Selective Oxidation: The Forefront in the Challenge for a More Sustainable Industrial Chemistry." The lecturer presented a broad survey of oxidation catalysis and described the most important achievements made in the industrial implementation of new oxidation reactions. These include the liquid-phase epoxidation of propylene with hydrogen peroxide (BASF-Dow and Degussa-Uhde companies), the gas-phase ammoxidation of propane into acrylonitrile (Asahi), and the liquid-phase ammoxidation of cyclohexanone with ammonia and hydrogen peroxide. A number of new processes is now at the scaling-up stage, and others are being developed in the laboratory. Note that the new processes replacing old ones are superior to the latter from both economic and environmental standpoints. This means that right steps are being taken to create a sustainable chemical industry. Prof. Cavani noted also that prolonged studies of some reactions had not been successful and put forward new ideas, particularly in the field of alkane oxidation.

Doctor E. Kondratenko, Leibniz Institute for Catalysis, University of Rostock (Germany), presented a lecture entitled "Using Time-Resolved Methods to Monitor and Understand Catalytic Oxidation Reactions." He pointed out the significance of the investigation of catalysis mechanisms at the elementary level, discussed the potential and limitations of various "stationary" methods, including their in situ variants, and dwelt on the study of transient kinetics in TAP (temporal analysis of products) reactors and on the SSITKA (steady-state isotopic transient kinetics analysis) method. These methods are very informative regarding the mechanism of both simple and complex reactions and allow the kinetic parameters of separate steps to be determined. This was illustrated with new data concerning the mechanisms and kinetics of high-temperature ammonia oxidation into nitrogen monoxide, propylene epoxidation, and the oxidative dehydrogenation of ethane and propane.

Prof. G. Veser, University of Pittsburgh (United States), presented a lecture entitled "Process Intensification through Integrated Reactor Concepts and

Nanoscale Catalyst Engineering.” The predictable depletion of cheap oil fields has rekindled keen interest in methane as an environmentally friendly alternative to petroleum. However, use of remote methane sources, as well as small-scale ones, such as biomass, needs new technological solutions. The lecture dealt mainly with the author’s own works on the design of integrated reactors and new nanocomposite catalysts for high-temperature fuel cells. By a number of examples, including partial methane oxidation into synthesis gas, the author demonstrated the possibility of enhancing the efficiency of processes by employing catalytic systems combining high activity and selectivity with thermal stability.

On the fifth, final day of the Congress, Prof. W. Kroutil, Department of Applied Biocatalysis, University of Graz (Austria), delivered a lecture entitled “Biocatalytic Oxidation: An Alternative or a Curiosity?” Biocatalysis has opened up great possibilities in carrying out selective reactions. Various kinds of selectivity are meant here, including chemical selectivity (when the substrate is converted into a single product because only one functional group participates in the reaction, while the other moieties of the molecule remain uninvolved), regioselectivity (when the enzyme is active only toward one of a number of similar groups), and stereoselectivity (when only one of the enantiomers/diastereomers is involved in the reaction). However, the remarkable selective properties of enzymes hide their flaw: in practice, it is often necessary to have a catalyst active toward a wide variety of substrates. In addition, the catalytic activity of enzymes is most pronounced at ordinary temperatures and in aqueous media. However, there are examples of use of enzymes in organic media and even in the gas phase. Undoubtedly, biocatalysis has a great potential, which is far from being completely utilized. Design of catalytic process needs joint efforts to be made by specialists in various disciplines, including organic chemistry, molecular biology, microbiology, biochemistry, and engineering.

Although the works presented at the Congress were quite diverse, there were persistently popular topics, such as instrumental methods mechanistic studies and alkane oxidation reactions. Increased interest was expressed in the use of renewable raw materials of vegetable origin. There was a notable tendency to broader understanding of the concept of partial or selective oxidation. At the time of the earliest meetings of the Congress, this term was understood as selective oxygenation of organic compounds conducted mainly on classical partial oxidation catalysts containing vanadium and/or molybdenum oxides. By now this concept has been appropriately broadened to include reactions that result to almost complete destruction of the initial organic compound, converting it into inorganic products (for example, selective methane oxidation into synthesis gas, i.e., CO and H₂).

Now we will consider some statistical data obtained by an analysis of the reports presented in Lille. Realizing that the division of all reports into oral communications and posters does not always reflect the real difference between the scientific levels of the works, we will nevertheless limit our consideration to only the oral reports made at the Congress. Besides, this will markedly facilitate the analysis since the number of oral reports is smaller. We will not make difference between ordinary oral reports, invited lectures, and keynotes, although this will not be quite fair to the lecturers.

Remarkably, there was a large number of joint works carried out by international teams. Out of the 23 key works, five ones (22%) were performed by authors from two countries or more. Out of the 116 oral reports, 40 ones (34%) are joint. This is also true for Russia: of the 11 works presented by Russian researchers, 4 ones were collaborative.

As for the total number of reports, the obvious leaders were France (23 reports) and Germany (18 reports). This large contribution from France is likely explained in part by the place where the Congress was held. Next on the list are Italy and Russia, which share the third and fourth places with 11 reports each. The ten most active countries include China, which presented six reports. Quite unexpected was the small contribution from Poland (one report), which always paid great attention to oxidation catalysis. Note the participation of a number of “necatalytic” countries, such as Venezuela, Argentine, Iran, Vietnam, Chile, and Romania, which presented one report each.

It is pleasant to note the strong position of oxidation catalysis in Russia. Our country presented two keynotes (M.G. Gantman, Moscow State University; O.A. Kholdeeva, Boreskov Institute of Catalysis, Siberian Branch, Russian Academy of Sciences). The first was devoted to the role of copper complexes with donor ligands in oxidation processes involving free radicals. The second dealt with polyoxometalate-based heterogeneous catalysts for selective liquid-phase oxidation. In addition, nine oral reports were presented, including six ones from the Boreskov Institute of Catalysis (Z. Ismagilov, M. Kerzhentsev, N. Mezentsева, L. Pirutko, V. Sadykov, and Yu. Chesalov); one from the Zelinskii Institute of Organic Chemistry, Russian Academy of Sciences (M. Botavina); one from Tver State Technical University (E. Sul’man); and one from Tomsk State University (L. Akatova). There were 18 poster reports from Russia.

The Congress paid tribute to Prof. Oleg Valentinovich Krylov, of blessed memory, whose name is held in high respect by the international catalytic community. Prof. Krylov was among the initiators of the Congress. From the first meeting to 2005, he was a member of its International Advisory Board. Prof. M. Misono, Chairman of the International Advisory Board, Presi-

dent of the Congress, opened the session of the Advisory Board with a minute of silence. Next, the author of this publication, Prof. Krylov's successor on the Advisory Board, shared his recollections of Oleg Valentinovich. Many warm words were also said by other members of the Advisory Board. M.Yu. Sinev, whose had been among Krylov's closest colleagues at the Semenov Institute of Chemical Physics for many years, prepared a stand devoted to this scientist and demonstrated it at the poster session.

The Congress took place in an atmosphere of comfort. Congress sessions were held at the Medical University of Lille in three lecture amphitheatres each seating several hundreds of people. A metro ride from the center of the city, where the hotels offered by the organizers were situated, to the University took no longer than 10–15 min. Owing to the generous sponsoring of the Congress, all participants were provided with free plastic transit cards. Metro is undoubtedly the basic public transport mode in Lille. It is quite comfortable and is famous as the first driverless metro in the world.

The participants were particularly grateful to the Organizing Committee for providing excellent

lunches (their cost was included in the participation fee). For this purpose, an incredibly large tent was set up on a lawn near the University, where all participants of the forum could easily take their places around pre-laid tables. Such lunches were organized for the first time in Krakow at the 3rd European Congress on Catalysis in 1997. A tent intended for accommodation of large units of Soviet troops was used there. In Lille, the organizers employed a NATO military tent, but this fact did not spoil the good appetite of Russian participants.

By tradition, the Lille Congress awarded a prize. This time the prize was given to Prof. M. Misono for his great contribution to the theory and practice of oxidation catalysis.

The Advisory Board accepted Prof. Grasselli's proposal to hold the next, 7th Congress in the United States.

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