



PROFESSOR DIETER WÖHRLE (on the occasion of his 80th birthday)

This special issue of *Macroheterocycles* is dedicated to Professor Dr. Dieter Wöhrle, University of Bremen, Germany, on the occasion of his 80th birthday. Born in Berlin on 18th of August, 1939, he studied at school in Lübeck and returned to Berlin to study chemistry at the Free University of Berlin. He received his master (1964) and doctoral degree (1967) from the Fritz-Haber Institute of the Max-Planck Society. After habilitation (1971, Free University of Berlin), he continued as an Assistant Professor at the Free University of Berlin. At the age of 35 he became a Full Professor of organic and macromolecular chemistry at the newly founded University of Bremen (1975). His past and present work at the University of Bremen include but not limited to: the head of the Institute of Organic and Macromolecular Chemistry, the dean of the faculty of Chemistry and Biology, researches at the Institute of Applied and Physical Chemistry, lecture courses on macromolecular and material chemistry, numerous grants from DFG, DAAD, Volkswagen Stiftung *etc.*



Dieter's group, end of the 70th/beginning of the 80th

His contributions extend through a broad field of science including organic, coordination, macromolecular and material chemistry, organic electronics, renewable energy, medicinal chemistry, catalysis and photocatalysis, green chemistry, science for peace.

He is an author and co-author of more than 400 scientific papers, approx. 20 patents and several books including: "Macromolecule Metal Complexes" (1996) with A. Ciardelli and E. Tsuchida; "Photochemie: Konzepte, Methoden, Experimente" (1998) with M.W. Tausch and W.-D. Stohrer; "Metal Complexes and Metals in Macromolecules" (2003) with A.D. Pomogailo; "Naturwissenschaft – Rüstung – Frieden. Basiswissen für die Friedensforschung" (2017) with J. Altmann, K. Nixdorff, U. Bernhardt and I. Ruhmann. The full publication list of Prof. Wöhrle up to 2019 is given in the Supplementary Information.

Professor Wöhrle is a member of the Gesellschaft Deutscher Chemiker, Board of Natural Scientists for Peace, a honorary member of the Azerbaijan Academy of Sciences, as well as an editor of several international journals including the *Macroheterocycles*. He is one of the founders of the MMC conference (with Prof. E. Tsuchida *et al.*), one of the founders and the European Editor of the *Journal of Porphyrins and Phthalocyanines* (with Prof. K.M. Kadish *et al.*). Many times he was a visiting professor in Russia and Japan.

His research activity in the field of macromolecular chemistry started with Prof. Georg Manecke in Berlin and included conjugated polymers from nitriles and macromolecular metal complexes, the latter extending over a broad range of ligand types and macromolecular arrangements. New coordination polymers, conjugated macromolecular Schiff base and salen complexes, tetraaza[14]annulene, hemiporphyrizine and phthalocyanine complexes and among them first examples of conducting polymers were prepared and investigated (approx. 1967–1978).

Professor Wöhrle is one of the classical authors in the phthalocyanine science which is confirmed by the Lin-



Professor Dr. Dieter Wöhrle in his laboratory in the University of Bremen (2012)

stead's lifetime award of 2004. He is active in this field for more than 50 years and has published more than 300 papers about phthalocyanines. He is well-known for his classical work on structurally uniform polymeric phthalocyanine metal complexes, including graphene-like polyphthalocyanine from tetracyanobenzene as well as conjugated and non-conjugated polymeric phthalocyanines with various Pc-Pc bridges. A large-scale high-dilution procedure for the preparation of octacyanophthalocyanine – an important precursor of polyphthalocyanines – was developed in his group. Preparative methods for structurally uniform polymeric phthalocyanines on various inorganic supports using various precursors were developed. Besides commonly used metals and their salts, volatile organometallic and coordination compounds were also used as metal sources (with Dr. O.N. Suvorova).

His contributions to preparative phthalocyanine chemistry are well-known to everyone working in this field. Some examples are: the dichlorophthalonitrile method for the one-step preparation of disubstituted phthalonitriles; synthesis of various substituted phthalocyanines in the presence of organic bases commonly known as the DBU method; solid state synthesis of unsymmetrically substituted phthalocyanines of the ABBB type on a polymeric support.

Professor Wöhrle studied low-molecular-weight and polymeric metal phthalocyanines in thin film semiconductor devices *i.e.* their conduction type, photovoltaic properties, electrocatalytic and photoelectrocatalytic performance. This research started early in Berlin with Prof. G. Manecke and continued in Bremen in collaboration with Prof. N. Jaeger, Prof. M. Kaneko, Prof. D. Schlettwein and Prof. J. Parisi. Organic photovoltaic cells exhibiting quantum yields of the photocurrent of up to 70 % were prepared. A pioneering report on the phthalocyanines as photosensitizers of inorganic semiconductors for dye-sensitized solar cells (DSSC) was published in 1999 with Prof. M. Grätzel. Other examples include phthalocyanines for photocatalytic water splitting (1982), electrocatalytic reduction of oxygen and carbon dioxide (1983 onwards), electrocatalysis in rechargeable lithium batteries (1985).

Phthalocyanine metal complexes are active catalysts for various oxidation reactions. Industrially important is the Merox (Mercaptan Oxidation) Process by using

cobalt phthalocyanines as catalysts. Professor Wöhrle and his group have made a large and important contribution to this field including extensive studies of catalytic activities of various water-soluble Pcs and their analogues, immobilized Pcs on inorganic and polymeric supports, *in situ* preparation of highly efficient catalysts based on cobalt polyphthalocyanine on various inorganic carriers as well as low-molecular-weight phthalocyanines covalently and coordinatively bound on modified inorganic carriers. Reliable experimental procedures for the catalytic activity measurements were developed. These studies were highly improved by Prof. Wöhrle's openness to collaboration with scientists from Germany and other countries (Prof. G. Schulz-Ekloff, Prof. A. Andreev, Dr. O.N. Suvorova). It was found that polyPcs are more active than low-molecular weight Pcs, and low-molecular-weight Pcs are more active if being adsorbed on conducting and semiconducting carriers. This was explained (1989) by the idea of a synergetic work of two metal centres connected by a conducting bridge, similarly to a short-circuited fuel cell.

His excellent work on the phthalocyanine catalysis was extended to photocatalytic oxidations of sulfide, mercaptans, phenols, chlorophenols, citronellol, cyclopentadiene *etc.* for waste water treatment and organic syntheses, especially in "green" conditions using molecular oxygen in aqueous solutions as well as solar radiation as the energy source. Typically, photoactive non-transitional metal phthalocyanines have limited photooxidation stability whereas photostable transitional metal Pcs widely used as dyes and pigments are not photoactive. Prof. Wöhrle and his coworkers (Dr. G. Schnurpfeil, Dr. R. Gerdes *et al.*) made a comprehensive study on the influence of the substituents, π -system extension and central metal ions of Pcs and porphyrins on the singlet oxygen quantum yields and photooxidative stabilities. A correlation between the photostability and the HOMO energy was revealed. These studies led to the development of highly photoactive and extremely photostable heterogeneous photocatalysts based on the ionically bound silicon phthalocyanines (2001 onwards). The panchromatic effect of a combination of photosensitizers with different absorption spectra on the photocatalytic activity was shown (2009).

Other research directions of Prof. Wöhrle's group include but not limited to: phthalocyanines as second-generation photosensitizers for photodynamic therapy (with Prof. M. Shopova, Prof. B. Röder, Dr. V. Mantareva, Prof. V.I. Bregadze *et al.*); liquid-crystalline network polymers (with Prof. M. Wark, Prof. G. Schulz-Ekloff, Prof. A. Hartwig); spectral hole burning and the world's smallest lasers based on organic dyes incorporated into zeolites (with Prof. G. Schulz-Ekloff, Prof. M. Wark *et al.*); reversible binding and membrane transport of oxygen by porphyrins in a polymer matrix (with Prof. H. Nishide, Prof. A.D. Pomogailo), nonlinear optical properties of non-aggregating Pcs in polymer films (with Prof. W. Blau); DNA sensing (with Prof. C.M. Niemeyer).

Large part of his scientific and social activity is dedicated to the peaceful use of science. He published several articles about chemical warfare agents and other "misuses of chemistry" such as chemistry and terrorism, drugs, polluting the environment by uncontrolled use of plastic



*With colleagues from Nizhnij Novgorod
Dr. S. Makarov, Dr. O. Suvorova*



*Discussion during seminar on Macroheterocycles
in Ivanovo (2012)*



Dieter together with Prof. Neal Armstrong in Tucson



*Discussion with Prof. Kunio Awaga during 8th Workshop
on organic electronics of highly correlated molecular systems
in Suzdal' (2018)*



Dieter's colleagues Prof. N. Jaeger, Prof. G. Schulz-Ekloff (1989)

materials. He attended various meetings and conferences against proliferation of chemical weapons. He raised questions of historical fairness of science. For example, it is known that IUPAC prohibits naming of the chemical elements after scientists involved in the development of nuclear weapons; the same must also apply to other aspects of science.



*Dieter's colleague Prof. Olga Suvorova and Dieter himself
with his tobacco pipe in Suzdal, Russia, 2011*

Prof. Wöhrle put forward the initiative of renaming the Fritz-Haber Institute due to F. Haber's activity in the development and use of chemical weapons in the First World War.

More than 60 PhD students made their doctoral theses in the group of Prof. Wöhrle. Besides them, many postdocs from Germany, Russia, Poland, Bulgaria, India, Japan, Azerbaijan *etc.* are grateful for unforgettable experience of working in his group, both scientifically and personally. In this respect, it is impossible not to note his hospitality and help to all guests of his group in all aspects of their visits.

Professor Wöhrle has very fruitful collaborations with research groups all around the world. He is very much liked by his friends and colleagues who enjoy working and interacting with him. Some of significant past and present research collaborations include but not limited to: Prof. M. Bauer, Teltow (Berlin); Prof. D. Blohm, University of Bremen; Prof. G.A. Domrachev, Dr. O.N. Suvorova, Prof. S.Yu. Ketkov, Nizhny Novgorod, Russia; Dr. D. Hommel, Prof. N. Jaeger, Prof. G. Schulz-Ekloff, University of Bremen; Prof. M. Kaneko, Ibaraki University, Japan; Prof. K. Leo, TU Dresden, Dr. O. Hild, IPMS Dresden; Prof. T. Nishisaka, Japan; Prof. I. Okura, Tokyo Institute of Technology, Japan; Prof. A.D. Pomogailo, Institute of Chemical Physics, Chernogolovka, Russia; Prof. M. Baumer, Dr. A. Wittstock, University of Bremen; Prof. A. Hartwig, University of Bremen; Prof. M. Wark, University of Old-

enburg; Prof. M. Shopova, Dr. V. Mantareva, Bulgarian Academy of Sciences, Sofia; Prof. H. Shirai, Dr. M. Suzuki, Shinshu University, Japan; Prof. E. Tsuchida, Waseda University, Japan; Prof. H. Yanagi, Nara Institute of Science and Technology, Japan; Prof. T. Yoshida, Yamagata University, Japan; Prof. W.J. Blau, Trinity college of Dublin, Ireland; Prof. J. Parisi, University of Oldenburg; Prof. D. Schlettwein, University of Gießen. He visited research groups in Moscow (Prof. A.D. Lukyanets, Prof. V.I. Bregadze, Prof. E.A. Karakhanov), Chernogolovka (Prof. A.D. Pomogailo), Nizhny Novgorod (Dr. O.N. Suvorova, Prof. S.Yu. Ketkov), Ivanovo (Prof. O.I. Koifman), Japan (different cities and research groups), Tucson, USA (Prof. N. Armstrong) and many others.

Prof. Wöhrle remains one of the most active scientists in the University of Bremen. Currently, he is working on a DFG project about phthalocyanines bound to nanoporous gold (with Dr. G. Schnurpfeil, Dr. A. Wittstock) utilizing the plasmon resonance effect for the enhancement of the Pcs photocatalytic activity. Other recent research activities include: consulting of the industrial companies (e.g. Solvay) on the production of phthalocyanines and their analogues for organic electronics (LCD, OLED, OFET and organic solar cells); theoretical studies on oligophthalocyanines for understanding the electronic structure of polymeric phthalocyanines.

*Dr. S. G. Makarov
Dr. G. Schnurpfeil*



*With Professors Tomas Torres
and Nagao Kobayashi (2018)*

Dear Dieter,

Let me express my most cordial congratulations to you with the occasion of your 80th anniversary! I am really proud to be your friend. You have been not only a pioneer and one of the most brilliant scientists and in the field of Phthalocyanines, but also my teacher.

As I told, I came to this area after reading your two excellent reviews in Kontakte (Darmstadt), more than 30 years ago! Unfortunately, I was not able to follow all your advices: losing weight is still pending; but I will do. I wish you a long, happy and healthy life.

Tomas Torres

**All colleagues, friends and the editorial board
of the *Macroheterocycles* wish Professor Dieter Wöhrle
a healthy long life and new scientific achievements!**