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Invited Letter

Enrico Drioli and Development of Membrane Science in Russia

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Enrico Drioli is an outstanding worldwide figure in membrane science and technology. Probably, the most frequent and anticipated answer to the question: "Who is Enrico Drioli?" would be, I suppose, "Creator and longtime president of the European Membrane Society." "Enrico is the motor" Patrick Meares told me many years ago, "without him everything would immediately stop." Of course, this is true, but much can be added to characterize the role of Drioli in developing different fields of membrane science and technology and his unique position among other distinguished specialists of the field. It seems to me that it is difficult to find an area in membrane science and technology where Enrico Drioli did not work and did not make a significant impact: gas separation, pervaporation, inorganic membranes, membrane distillation, membrane contactors, ultrafiltration, microfiltration, membrane catalysis and membrane reactors, membrane crystallization, and integrated membrane processes. This is the list of the areas where he was active, and it apparently can be extended.

It is necessary to emphasize a tremendous role played by Drioli in development of international collaboration in various fields of membrane science and technology and his support to initiate membrane studies in the countries where they had been in a rudimentary state (e.g. in Central and East Europe). Later his interests moved to the Far East, and he helped to organize modern membrane centers in China and the Republic of Korea.

In this communication, I would like to briefly outline the role of Enrico Drioli in development of membrane studies in Russia based on my personal recollections. With the help of Drioli, isolated small centers of membrane studies first in the Soviet Union and then in Russia became involved in international collaboration with numerous universities and industrial companies in Europe and USA. The level of their work was enhanced and they started to participate in international programs such as INTAS, INCO-Copernicus and Framework Programs of European Society.

I remember our first meeting with Enrico Drioli very well. It was in Prague at one of the famous "Microsymposiums on macromolecules" where Drioli delivered an excellent lecture on membrane distillation. Dr. Sergei Durgaryan, the founder of the membrane laboratory in A.V.Topchiev Institute of Petrochemical Synthesis (TIPS) and I attended this conference and were impressed by his talk and possibilities that appear due to application of membrane distillation for energy saving desalination of sea water. Drioli was invited to visit TIPS, and this visit indeed took place during the next, 1987, year (so about 30 years ago).

In 1989, the first international membrane conference in the Soviet Union was organized with the active support of Drioli. The venue of this conference was the ancient Russian town Suzdal located not far from Vladimir, the town where the greatest Russian company Polymersyntez (later Vladipor) was located. The plenary lecture in it was read by Drioli (see Figure 1).

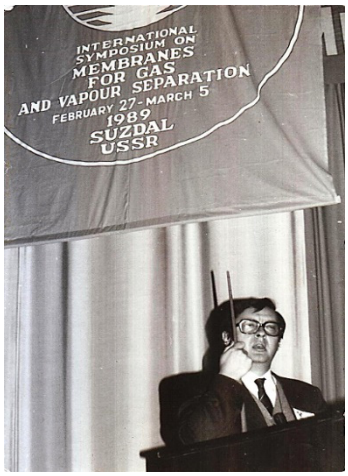

Fig. 1. Plenary lecture at Suzdal conference (1989).

During the days of this conference warm personal relations between Drioli and the management of this company were established. They were fostered during subsequent numerous visits of Drioli to Vladimir. Vladipor took part in several international projects headed by Drioli or where Drioli was the director of the Institute of Technology of Membranes, ITM (Italy) took place.

During that period, a long-term friendship started between Enrico Drioli and Nikolay Plate, director of TIPS and head of Membrane center in this Institute (see Figure 2). They coordinated international projects, organized conferences with participation of Russian specialists in membrane science and technology.

The next important event for the Russian membrane community was the

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organization of the Summer school of European Membrane Society in 1991. Enrico Drioli also took active part in its preparation (see Figure 3). The Summer school was scheduled on the first week of September. It happened so that the coup took place in Russia in the end of August, and the organizers were afraid that many speakers originally announced their participation would refrain from coming. However, this did not happen, and the Summer school was one of the most successful by the list of speakers.

Fig. 2. Nikolay Plate and Enrico Drioli.

Fig. 3. During coffee break at Summer School in 1991.

During subsequent years, Enrico Drioli actively collaborated with different groups in Russia. Especially fruitful and numerous were his contacts with several laboratories of TIPS. Thus, the laboratory headed by Professor Vladimir Gryaznov developed original concepts of catalytic metallic membranes for realization the reactions of hydrogenation and dehydrogenation in the same reactor, the filed that was of great interest for Drioli's group. Joints efforts of this laboratory and Institute of Technology of Membranes (ITM CNR) headed by Drioli resulted in several interesting publications in this field.

Interesting work was performed by ITM and TIPS under the framework of an INCO-Copernicus project on the use of oxygen enriched air in the processes of combustion and gasification of low grade coals. It was shown that energy efficiency can be strongly improved if the coal is treated not by air, but by O_2/N_2 mixtures with enhanced concentration of oxygen obtained using gas separation membranes based on poly(vinyltrimethyl silane). This work had practical importance because there are large sources of low grade coal with high ash content in Russia. Gasification of such coals by air is inefficient because of diffusion limitations.

In late 1990s, ITM and TIPS started joint studies of membrane properties of perfluorinated polymers. The object of the investigation in ITM were Hyflon AD copolymers, while in TIPS detailed studies were conducted on membrane properties of amorphous Teflons AF. For these copolymers not only gas permeation parameters, but also free volume were studied using photochromic probes and positron annihilation lifetimes spectroscopy. It was shown that they demonstrated attractive combination of gas permeability and permselectivity especially for such gas pairs as He/CH_4 or CO_2/CH_4. Efforts of both groups were also directed to computer modeling of the structure of these perfluorinated polymers. Another direction of joint research of ITM and TIPS was development of membrane contactors. In TIPS, this activity was realized mainly in the laboratory headed by Vladimir Volkov.

The role of Enrico Drioli in developing membrane science and technology in Russia was highly acclaimed: he was awarded a title of Doctor Honoris Causa of the Russian Academy of Sciences. Enrico Drioli served also as the foreign member of TIPS.

Enrico Drioli is a great traveler. It is difficult to find a country in the globe which he has not visited. While traveling, he always has a keen interest in history, art and traditions of the country. After his many visits to Russia, he has gathered a good collection of Russian folk painting and icons. Figure 4 shows Enrico Drioli and the author of this letter during the excursion to Moscow Kremlin (in front of so-called Tsar-Gun). Both of us were much younger than we are today.

Fig. 4. Yuri Yampolskii and Enrico Drioli in Moscow Kremlin.

Yuri Yampolskii, Russia (2019)