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Introduction: Ten years after the first international conference on mechanochemistry and mechanical alloying; where we are now

As one of the veterans of mechanochemical research, I would like to say a few words concerning our conference.

It is worthy reminding, that the INCOME conferences were preceded by other international conferences and symposia, at which the problems of mechanochemistry were discussed, mechanochemistry being included in the general program as a section. I mean the Soviet-German Conferences on Mechanochemistry and Mechanoemission originating from the Meeting in Frunze in 1968, TATARAMAN Symposia held by the Mining Institute of the Slovak Academy of Sciences, Soviet-Japanese Symposia on Mechanochemistry, and the organization of the International Mechanochemical Association (IMA), which eventually became an associated member of the IUPAC.

INCOME conferences were a logical continuation of this work. I would like to remind, that the first INCOME was organized in Košice (Slovakia) ten years ago under the initiative of Professor K. Tkáčová. And now we are experiencing the 4th INCOME here in Braunschweig.

The number of reports presented at the 4th INCOME, the multi-aspect character of the research, a very representative membership (279 reports from 40 countries have been presented; please see also Fig. 1) are very impressive. This means, that mechanochemistry, the science dealing with the physicochemical transformations of solids induced by mechanical action, is no longer a "Cinderella or Ugly Duckling science," which was not taken seriously twenty or thirty years ago. Mechanochemistry now has won the right for recognition and the right for citizenship.

Number of publications in mechanochemistry is rapidly increasing. Sometimes optimists say that it is developing with lightning speed. However, if we compare mechanochemistry with a lightning, it is better to speak not of the speed of its development, but of its zigzag character.

In the beginning, which was the end of the XIX-th century, it was the accumulation of facts related to unusual processes, which occurred during mechanical treatment, of the facts establishing the possibility to perform synthesis in the dry state and of the facts evidencing that a solid after mechanical activation starts to change its physical and chemical properties substantially, its composition being preserved. This was the period of observations and collecting facts, similar to how this was done in such areas as botany and geography.

Figure 1 Participants of the 4th International Conference on Mechanochemistry and Mechanical Alloying (INCOME 2003), September 7–11, 2003, Braunschweig, Germany.

The time for collecting experimental facts has expired. There are several reasons for this. First, the apparent simplicity of a mechanochemical experiment. Really, everybody possessing at least a mortar with a pestle considers himself to be a mechanochemist quite ready to perform mechanochemical investigations; if he succeeds in attaching a motor to that mortar, this would be already a mechanochemical center. To our regret, this stimulated the try and error method, which resulted in the publication of many communications reporting the observed effects. Unfortunately, only very few publications consider the origin of the mechanochemical effects and the mechanisms of mechanochemical processes.

It is time to analyze the obtained results and to search for the explanation of the observed phenomena. One probably cannot stop appearing publications simply reporting on the effect of a treatment in a mill on one chemical process or on another; new effects and new systems are always interesting. However, it is now more important from the strategic viewpoint to investigate the mechanisms of mechanochemical transformations, and not only to observe but also learn to predict mechanochemical effects, not only to follow mechanochemical processes, but also to control them. In order to perform such a research, it is necessary to move from a traditional mechanochemical apparatus to a model set-up, in which it would be possible to separate the influence of pressure, pressure and shear, impulse relaxation, etc. It is impossible to investigate aerodynamics using an aircraft as the object of investigation; similarly, it is impossible to investigate the nature of mechanochemical effects in a mill.

Another goal is to train experts in mechanochemistry and mechanical activation. As far as I know, mechanochemistry and mechanochemical activation are absent from a standard curriculum. The absence of teaching in the area of mechanochemistry is to a great extent the reason of the trial method which I mentioned earlier. One does not need great intelligence to put something into a mill and to look what will happen. It is necessary to achieve the recognition of mechanochemistry in the system of higher education, after it has eventually won the right of citizenship in science. This is an urgent problem of today. We are to get ready, to prepare manuals, books, educational materials-everything necessary for teaching and learning.

The third topic of my speech will be the problem of the practical application of the achievements of mechanochemistry. Here we have also come across difficulties, which force us to advance in a zigzag way instead of going straight. Namely, a traditional and initially established approach aiming at the application of mechanochemistry in such a large-scale industry as metallurgy or production of the construction materials did not meet the expectations. First of all, economical, highly productive, efficient high-energy mills have not been developed yet. Second, mechanical energy is yet too expensive. As a result, mechanochemical technologies are not sufficiently efficient due to purely economical reasons. Third, what is important in some cases, too, the contamination due to the wear of milling bodies of a mechanical activator can decrease the purity of the final product. This creates the problems related to the necessity to purify the final product after mechanical activation and therefore to add more stages into the technological processes. This may be not very important for the intensification of hydrometallurgical processes, but in the case of mechanical alloying or synthesis and modification of the catalysts this can play an important role.

Experience suggests, that the application of mechanochemistry is more promising in the small-scale and expensive technological processes (such as the synthesis of functional ceramics, the modification of properties and the synthesis of pharmaceuticals, the production of nanosized catalysts, fine organic synthesis, etc.). It is this area, in which the applications of the mechanochemistry can be expected to be very promising, since the existing devices are quite adequate, one can do without huge energy strain values, energy consumption is not high, while the gain in the process rate and, in some cases, also in selectivity can be achieved.

I believe that a progress in these three directions—fundamental research, education, applications—will stimulate the successful development of mechanochemistry, and we will see the confirmation of this at the future INCOME.

To conclude, I think that we all should thank the organizers of the conference and especially Professors V. Šepelák and K. D. Becker for the excellent organization of INCOME 2003 and also to send a greeting to Professor K. Tkáčová who has initiated the first INCOME ten years ago. Finally, I would like to mention that the publication of the proceedings of the 4th INCOME in the Journal of Materials Science is highly appreciated by the Conference Committee and participants. We especially appreciate the personal contribution of Professor Zuhair A. Munir for his effort in this direction.

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