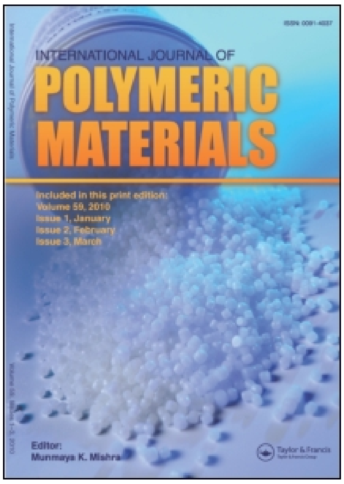

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G. E. Zaikov[a]; A. Ya. Polishchuk[a]
[a] Institute of Chemical Physics, Russian Academy of Sciences, Moscow, Russia

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Polymer Flammability

G. E. ZAIKOV and A. YA. POLISHCHUK

Institute of Chemical Physics, Russian Academy of Sciences, 4, Kosygin Street, Moscow 117334, Russia

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The annual session of the Polymer Flammability Group of the Scientific Council on Combustion and Explosion* focused on the scientific activity of the Institutes of the Russian Academy of Sciences in the area of polymer flammability. The members of the council and invited experts, about 100 scientists from 15 research centers of the Russian Academy, participated in this session.

After the opening remarks were made by Professor A. D. Margolin (Institute of Chemical Physics, Moscow), four reviews were discussed.

The lecture of Dr. Alexey M. Antonov and Professor Nikolai A. Khalturinskii (Institute of Synthetic Polymeric Materials, Moscow) addressed the development of polymer materials with fire retardancy. It was shown that the increase of the thermal stability of polymers was successful in retarding the flammability of polymeric materials. New rigid-chain polymers as well as crystal and liquid crystal structures with high thermal stability have been developed. A second effective way to retard polymer flammability that was discussed, was the polymer-analogous reactions, the idea of which is the involvement of chlorine or bromine atoms in the polymer or polymer goods. The major disadvantage of this method is the change of physico-mechanical properties of polymer.

Some work also has been done on further application of antipyrenes for fire retardancy of polymer materials, although certain resistance of environmental champions to this investigation should be mentioned. One of justification for such resistance is the formation of a great amount of toxic compounds (particularly, dioxine) during the combustion of polymers, if bromine-containing, low molecular weight antipyrenes are applied. This problem can be particularly solved, if macromolecular, bromine-containing antipyrenes are applied instead of low-molecular ones. In this case, the yield of dioxine is much less.

The main idea of modern research is to avoid an application of galogen-containing antipyrenes and to develop the foaming systems (foam char). These systems could

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*The Scientific Council on Combustion and Explosion was founded by the Presidium of the Russian Academy of Sciences. The head of the council, Professor Alexandre G. Merzhanov, is a well-known scientist and author of the theory of self-spreading, high-temperature systhesis. The head of the Polymer Flammability Group is Professor Arkadii M. Margolin.

be divided in two groups: one which does not contain a polymer and one that does. Ammonium polyphosphate and pentaerythrol are often applied for the components of latter system. Also, the salts of alkali metals of organic acids are successfully applied for the same purpose. For example, the presence of 1% of such salts reduces the thermal stability of polycarbonate, but more CO_2 and more non-soluable char residue appear at lower temperature. In this case, Fries rearrangement starts, and the polymer forms branched, crosslinked structure and takes part in the foam char formation.

Great attention is concentrated on the fire retardancy of polymer blends, alloys and composites. It has been shown that antipyrenes that are effective for some polymers become non-effective for polymer blends. Professor Guennadii E. Zaikov (Institute of Chemical Physics, Moscow) showed convincing evidence of complicated mechanism of co-oxidation of polymer blends. Following this mechanism, some unexpected effects can be explained by the different reactivity of alkyl and peroxyl radicals that appear in polymer blends. Particularly, Professor N. A. Khalturinskii showed that addition of ABS-plastic to polycarbonate leads to sharp reduction of the efficiency of antipyrenes of salts of alkali metals of organic acids. The Fries rearrangement is not observed in the presence of ABS-plastic.

Research has developed on the application of inorganic fillers ($Al(OH)_3$, $Mg(OH)_2$), etc. as antipyrenes.

One of the most important problems is antipyrenes sweating. Application of high-molecular weight compounds or microcapsulation of antipyrenes is proposed as a way to solve this problem. In particular, microcapsulation is required when applying red phosphorus as an antipyrene to avoid an oxidation of phosphorus to phosphine.

Another important problem is the reduction of physico-mechanical parameters of polymers under loading antipyrenes. One way to solve this is to search for new and more effective antipyrenes, which could be used in lower quantities. The synthesis of antipyrenes in the melt polymer is an effective method to load antipyrenes in polymer matrix.

Surface treatment of polymeric materials was also considered as a means to retard their flammability. Using this method, the crystals appear on the surface and do not change the mechanical properties of polymer material as a whole. Advantages and disadvantages of thermal treatment as well as laser and plasma treatment of polymeric materials were examined in detail.

One of the approaches to surface modification is to load low molecular weight organosiloxanes in the polymer matrix. The result of sweating and thermal treatment of these compounds is the formation of quartz "stocking upon the surface," which is followed by sharp fire retardancy of the material.

N. A. Khalturinskii and A. D. Margolin showed a way to retard polymer flammability that had not yet been applied. This was to load additives, which increase the reflection coefficient of light energy. In particular, antimony oxide promotes the reflection of light energy and, therefore, retards a flammability of polymer materials.

The aforesaid problems were discussed in great detail by Professors L. M. Stesik and S. S. Rybatin (Chernogolovka Institute of Chemical Physics, District of Moscow); I. A. Ossovsky, N. N. Bakhman, G. E. Zaikov, A. D. Margolin, V. G. Krupkin and V. M. Laloyan (Institute of Chemical Physics, Moscow); N. A. Khalturinskii and A. M. Antonov (Institute of Synthetic Polymeric Materials); and others.

The next lecture was given by Professor Nikolai N. Bakhman who reviewed the regularities of the flame propagation on the surface of polymer materials. The mechanism and kinetic regularities of the flame propagation have been studied at the quantitative level. The effect of the nature of the polymer and fillers; the contribution of shape and size of molecules in this effect; the influence of ambient conditions; heat sources; and the existence of convective flux were considered.

In the case of composites, the rate of propagation strongly depends on its direction (along or cross fiber). This applies if the thermoconductivity of the fiber substantially differs from the thermoconductivity of resin filler. The contribution of convective flux was considered with regard to some concrete examples: the fires at the KAMAZ Automobile Plant and the "Slavyanskii Bazar" Hotel in Moscow. The effect of porosity, thickness, temperature, and oxygen concentration was also considered.

The next lecture, given by Dr. Sergei M. Laloyan, was a scientific report from the Department of Polymers and Polymer Composites of the Institute of Chemical Physics, headed by Professor Alexandre A. Berlin. Dr. Laloyan addressed research on flame propagation on the surface of composites. Following evidence about the mechanism of the process, equations were proposed that enable prediction of the rate of flame propagation for known experimental conditions and properties of polymer composites. A. A. Berlin and S. M. Laloyan developed the research that enabled prediction of the fire parameters on the basis of properties of considered system. Monolithic materials, foam polymers, composites, and filled polymers were considered from the aforesaid point of view. Clear dependence of the combustion rate on the oxygen index was illustrated for many polymers.

Many scientists from different institutes discussed this lecture. The high quantitative level of research was emphasized with regard to the influence of American investigators and in particular, the research of Professor Takashi Kashiwagi from the National Institute of Standards and Technology was mentioned.

The last lecture, entitled "Critical Diameter of Heterogeneous Combustion Transfer," addressed more applied research. It was presented by Vladimir G. Krupkin (the speaker), A. D. Margolin, and G. N. Mokhin. It is well known that the ignition of material is facilitated in the corners and edges. This lecture discussed the regularities of ignition of polymers that followed the flammability of wedge-shape and cone-shape edges (for example, "needles"). The period of the ignition of the polymer strongly depends on the value of the top corner of the cone. The authors considered the conditions that are required for the transfer of ignition from the "needle" to the polymer body. It was shown that the limited value of the diameter of "needle" (d_{lim}) exists. The polymer body is not flamed if the needle is thinner than d_{lim}. The slope of the needle to polymer body is also substantial for the ignition.

The session showed that in spite of economical problems, the part of scientists develop their research. Unfortunately, it will come to an end very soon if the government does not change its position toward funding scientific research. This is evidenced by the fact that no equipment or chemicals were purchased during the past three years.

We hope to describe the development of events in our forthcoming paper in December 1994.