

## SOME SPECIFIC CHARACTERISTICS OF THE FRACTURE OF STRESSED POLYMERS IN AGGRESSIVE MEDIA

Yu. K. Volkov

UDC 678.742: (539.376+539.434)

Published data on the chemical stability of polypropylene in various aggressive media [1-4] relate to specimens in a stress-free state. These data cannot be used to estimate the reliability of parts working under stress, since the fracture of stressed plastics in aggressive media is, as a rule, substantially different from that of unstressed specimens.

We studied the effect of various aggressive media on polypropylene (both unloaded and under stress) by x-ray diffraction, nuclear magnetic resonance (NMR), electron paramagnetic resonance (EPR), and infrared spectroscopic analyses.

Examination of the infrared spectra and spectra of the broad bands of NMR and EPR for polypropylene exposed to air, a 10% NaOH solution, a 10% HCl solution, and 3%, 30%, and 60% H<sub>2</sub>SO<sub>4</sub> solutions showed no evidence of any chemical reaction between polypropylene and any of these media up to 100°C. It may therefore be concluded that unstressed polypropylene is perfectly stable in such working media as water and salt and in acid and alkaline solutions. However, this does not apply to stressed polypropylene. Thus, the strength of polypropylene under the influence of sulfuric acid is increased; this effect, whose intensity increases with acid concentration, is manifested as an increase in its breaking stress and as a reduction in its creep rate. In contrast, the breaking stress of polypropylene in water and, especially, in alkaline solutions is sharply reduced and its creep rate increased.

On the basis of tests on unstressed polypropylene, it was concluded in [5] that this material is not liable to crack in alkaline media. Photographs reproduced in Fig. 1 show clearly, however, that cracking does occur in polypropylene under the combined influence of stress and alkaline solutions. "Silver" cracks covering the entire specimen surface may appear in polypropylene stressed in a 10% NaOH solution (see

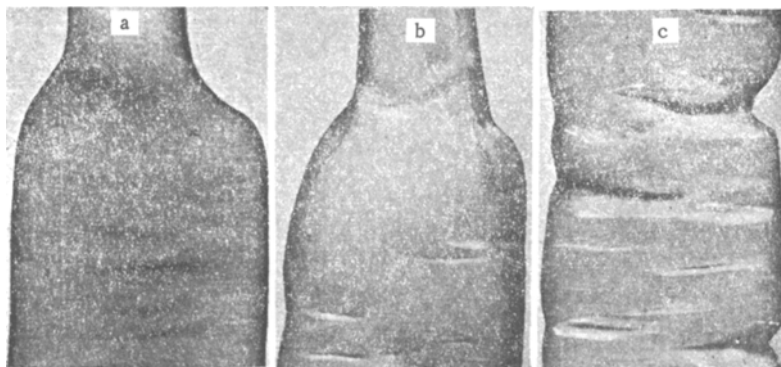


Fig. 1. The surface of a polypropylene specimen ( $\times 10$ ) exposed to a 10% NaOH solution: a) at 60°C,  $\sigma_0 = 136$  kgf/cm<sup>2</sup>, and for an exposure of 2000 h; b) at 80°C,  $\sigma_0 = 102$  kgf/cm<sup>2</sup>, exposure of 1500 h; c) at 100°C,  $\sigma_0 = 102$  kgf/cm<sup>2</sup>, and for an exposure of 800 h.

Branch of the All-Union Scientific-Research Institute of Chemical Methods of Plant Protection, Shchelkovo. Translated from *Fiziko-Khimicheskaya Mekhanika Materialov*, Vol. 5, No. 6, pp. 753-754, November-December, 1969. Original article submitted August 28, 1968.

© 1972 Consultants Bureau, a division of Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y. 10011. All rights reserved. This article cannot be reproduced for any purpose whatsoever without permission of the publisher. A copy of this article is available from the publisher for \$15.00.

Fig. 1a). The neck formed in specimens tested under these conditions has a flaky surface. At higher temperatures the "silver" cracks do not, as a rule, appear; in this case, the cracks are deeper and the surface of the neck is smooth (photograph b). At temperatures approaching the boiling point of a given alkaline solution, the entire surface becomes covered with deep cracks (photograph c) which do not close up when the specimen is unloaded.

No cracking was observed in stressed and unstressed polypropylene specimens tested in air and in acid media at temperatures of up to 100°C. Raising the temperature to 140°C leads to certain changes in the nature of the influence of these media: at this temperature the reaction between polypropylene and working media of this kind leads to its thermal and oxidation-induced destruction. These conclusions are in agreement with infrared spectroscopy and EPR data. (Only the effect of air and a 60% H<sub>2</sub>SO<sub>4</sub> solution on polypropylene at 140°C was studied, since the boiling points of other media studied is considerably below this temperature). It was found that the surface of stressed polypropylene ( $\sigma_0 = 26 \text{ kgf/cm}^2$ ) in 60% H<sub>2</sub>SO<sub>4</sub> at 140°C darkens after 100 h; in the case of unstressed polypropylene, this effect is observed only after 400-500 h. Darkened specimens are less elastic and their creep rate is much lower.

Although the thermal and oxidation-induced destruction of polypropylene in air is much lower than it is in sulfuric acid, it must be taken into account in the design of structures whose load-carrying capacity is an important consideration.

#### LITERATURE CITED

1. V. I. Pilipovskii and I. K. Yartsev (eds.), Polypropylene [in Russian], Izd. Khimiya (1967).
2. G. Menges, Z. Schweiss. Techn., 55, No. 4, 123 (1965).
3. O. Pesta and S. Friderich, Kunststoffe-Rundschau, No. 10, 510 (1963).
4. D. S. Hings, Brit. Chem. Eng., 8, No. 12, 823 (1963).
5. T. Kresser, Polypropylene [Russian translation], IL (1963).