Effect of Antioxidants on Polyethylene

By Shigeharu Okamoto and
Keisaku Takeuchi*

(Received January 9, 1959)

It is well known that oxidized polyethylene contains some amount of oxygen. Infrared spectrophotometric studies[1] have shown that during oxidation carbonyl groups are formed. The presence of these polar groups should be readily detected by measurements of the dielectric losses which imply the existence of the rotation of the polar groups under the influence of an externally applied alternating electric field. The oxidation resistance of polyethylene can be improved by the use of certain inhibitors and it is to be expected that increased knowledge of the effect of antioxidants on polyethylene will contribute toward this improvement.

* Present Address, Kijima Communication Wire Co., 6-1252, Kamimeguro, Meguro-ku, Tokyo.

1) F. M. Rugg, J. J. Smith and R. C. Bacon, *J. Polymer Sci.*, 13, 535 (1954).

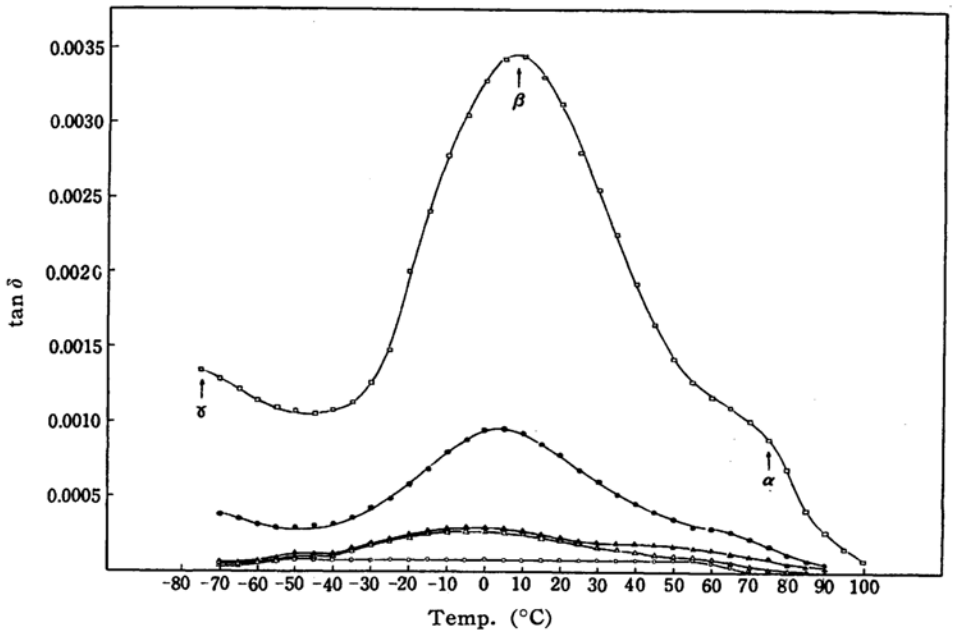

Fig. 1. The dissipation factor as a function of temperature for polyethylene exposed to ultraviolet radiation. Frequency 10 kc./sec. ○ before exposure; △ (20 hr.) and ▲ (40 hr.) exposure, with an antioxidant; ● (20 hr.) and □ (40 hr.) exposure, without antioxidant.

In this view we have studied the effect of an antioxidant on the change of the dielectric losses of polyethylene during aging. The polyethylene examined was Alathon 10-NC10-Natural and the antioxidant chosen was α-naphthylamine. A small amount of the antioxidant (1% by weight) was added on an open mill into the polyethylene sample. The photo-oxidation of polyethylene specimens has been carried out by exposure to the ultraviolet radiation from a mercury quartz lamp during 20 and 40 hr. Dielectric measurements were made over a temperature range of -75 to $+100$°C at a frequency of 10 kilocycles per sec. The results are given in Fig. 1.

As shown by the graph, for polyethylene samples containing no antioxidant, there exist three loss peaks and the maximum heights of the peaks increase as the time of exposure is increased. It is customary to label these peaks as α, β and γ descending from higher temperatures. On the other hand, far polyethylene samples containing a small amount of antioxidant, the α and β loss peaks which are attributed to the carbonyl activity in the crystalline regions and to that in the amorphous regions respectively, are markedly small and remain almost unchanged in intensity, independent of increasing exposure time. Furthermore, the γ peaks are missing as does that of original polyethylene sample before exposure.

It is concluded from the results that dielectric measurement is a sensitive method to estimate the degree of polarity of oxidation products and α-naphthylamine can be established to be an effective oxidation inhibitor for polyethylene by the use of dielectric method too.

Department of Applied Physics
Waseda University
Shinjuku-ku, Tokyo