day at the start, the total losses after 35 days of treatment were 43% and 47% in the lots receiving terramycin and 85% in the controls.

The data obtained from the third experiment, which gave about average results, are presented in Table 1.

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Initiation of Vinyl Polymerization by Means of High-Energy Electrons

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The recent development of equipment able to deliver controlled amounts of high-energy electrons suggested a continuation of the studies of polymerization of unsaturated compounds started by W. D. Coolidge in this laboratory in the 1920s (*1*). The initiation of vinyl polymerization by means of γ-rays has been the subject of recent investigation (*2–5*). The only report in recent years of the use of high-energy electrons for this purpose indicated negative results (*6*).

In the present investigation, a cathode-ray generator of the resonant transformer type, operating at 800 kvp, has been employed. It has been found that high-energy electrons can induce the polymerization of various monomers, including acrylates, methacrylates, styrene, and acrylonitrile. The susceptibility toward polymerization by this method is in the order given. Difunctional vinyl monomers, such as tetraethyleneglycol dimethacrylate (TEGMA), polymerize much more than monomers containing only one double bond. Thus, irradiation of 1-ml samples, in air, with 2.5×10^6 equivalent roentgens (R)[2] accumulated in 17.5 sec, produced only 1% of high polymer from methyl methacrylate. Similar irradiation in the case of TEGMA produced a solid polymer in which 45% of the double bonds had been utilized, as measured by heat evolution. The electrons appeared to function as catalysts in initiating chain growth; the number of double bonds reacting per ion pair was of the order of 10 in the former case and 500 in the latter. In the polymerizations studied, the conversions were increased by either an increase in the dose or an increase in the length of time employed to administer the same dose.

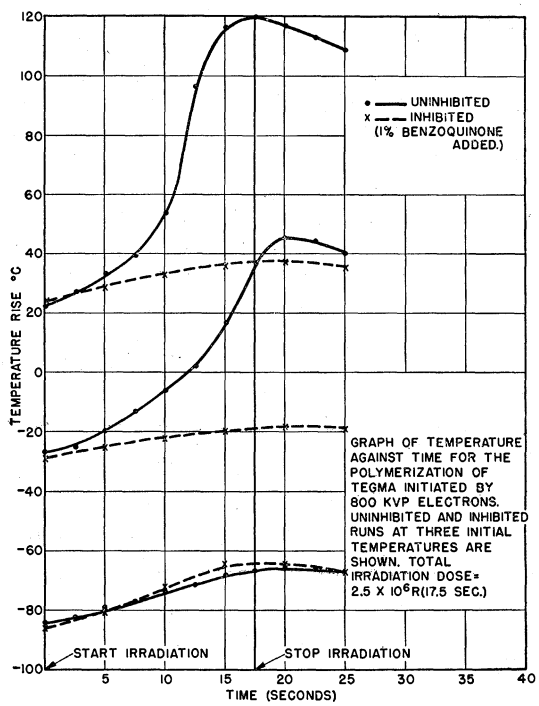

FIG. 1.

Since materials can be irradiated at any temperature without undue temperature rise from irradiation, it was of interest to determine whether there was a minimum temperature at which polymerization could be induced. For this purpose, the polymerization of TEGMA was examined in some detail by measuring the temperature rise caused by its heat of polymerization. The measurements were made by means of a thermocouple immersed in the monomer contained in a small Petri dish. The output of the thermocouple was connected to a G-E photoelectric potentiometer recorder, so that the temperature of the sample could be measured before, during, and after irradiation. The Petri dish was supported on an aluminum block in a Dewar flask and covered by a thin sheet of aluminum. The initial temperature of the sample was regulated to a constant value by cooling or warming it and the block. In all cases, 5-ml samples of TEGMA were irradiated with total doses of 2.5×10^6 R accumulated steadily over 17.5-sec periods.

The curves in Fig. 1 show the temperature rises at various times, after start of irradiation and at three widely different initial temperatures. Since the temperature rise of the polymerizing sample during irradiation was a result of both the heat of polymerization and the irradiation energy, it was necessary to make a correction for the latter. Similar measurements, therefore, were carried out with samples of TEGMA containing 1% benzoquinone, which completely inhibited polymerization. Inhibited runs corre-

[1] The authors wish to acknowledge the valuable assistance of John S. Balwit, of this laboratory, in the experimental work.

[2] Equivalent roentgen measurements were made with a special air ionization chamber. Values given are those incident at the surface of the monomer.

sponding to the polymerizing runs are also presented in Fig. 1. The difference between the inhibited and polymerizing curves represents the temperature rise due to polymerization alone.

An inspection of the curves of Fig. 1 indicates that polymerization occurs at $-20°$ C but not at $-80°$ C. From a number of other such comparisons, it was found that the minimum temperature at which polymerization occurred was between $-50°$ C and $-55°$ C, which is also the range in which TEGMA hardens into a glassy solid. The apparent limiting temperature, $-55°$ C, is to the best of our knowledge the lowest temperature at which free radical polymerizations have been observed.

In TEGMA samples irradiated at temperatures lower than $-55°$ C, polymerization did occur on warming, but only after the material had reached a semifluid state. Such delayed polymerization was observed even after storing the sample at dry-ice temperature for several days.

The polymerization of TEGMA showed inhibition by both benzoquinone (Fig. 2) and oxygen (Fig. 3),

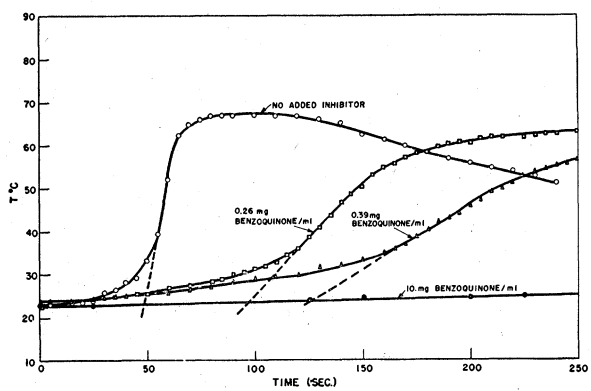

FIG. 2. Graph of temperature against time for the polymerization of TEGMA containing various amounts of added inhibitor. The polymerizations were initiated by 800 kvp electrons using a dose rate of 5.2×10^3 R/sec.

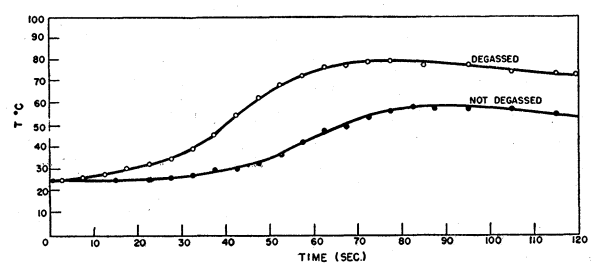

FIG. 3. Graph of temperature against time for the polymerization of TEGMA initiated by 800 kvp electrons—using 3.75 μa, 10 cm from the tube window—indicating the effect of air (oxygen).

which is characteristic of free radical polymerization. On the basis that this is a free radical reaction, the number of radicals formed can be calculated from the induction period (Fig. 2) resulting from small amounts of benzoquinone (*3*). If it is assumed that one quinone molecule stops one free radical chain, the results indicate that 5.4×10^{18} radicals/ml TEGMA/10^6R are formed as opposed to calculated ion pair yields of 1.8×10^{18} ion pairs/ml TEGMA/10^6R.

The polymerization of cross-linking monomers (e.g., TEGMA), initiated by high-energy electrons, was found to be dimensionally specific and could be used to form shaped objects in a pool of monomer. The lateral dimensions could be regulated by interposing a lead sheet, in which a design had been cut, between the monomer and the irradiation source. The thickness was determined by the electron energy and increased as the kvp was increased, indicating that the polymerization did not propagate beyond the region of ionization and radical formation.

Further work is being done to extend this method of polymerization to other monomers and co-monomers and, if possible, to still lower temperatures.

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Early Sexual Development and Growth of the American Oyster in Louisiana Waters

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Several investigators have noted the early sexual development of the American oyster, *Crassostrea virginica* (Gmelin) (*1–5*), in connection with sex reversal studies. Coe (*2*) states that from South Carolina southward young oysters of both sexes reach sexual maturity when only 10–12 weeks of age. In another publication (*3*) he says that well-nourished individuals of the early set on the coast of North Carolina and the Gulf of Mexico spawn when only 3 or 4 months of age. Burkenroad (*4*) found sexual development in some Louisiana oysters 20 mm or less in length.

The writer, working in the waters of Terrebonne Parish in Louisiana, has examined a total of 1,431 oysters in which sex could be determined, during the period August 1947–March 1949. Several hundred other oysters were examined in which the gonads were not well enough developed to make determination of sex positive by the method used. All the data were obtained by examination of fresh unstained preparations. The oysters were preserved after study of fresh smears, and examinations of a number of prepared slides stained with Heidenhain's hematoxylin and eosin have corroborated the initial findings.

Of the total number of oysters examined during the period, 1,179 were of known maximum age, as they were attached to culch that had been planted at a

[1] Researches on oysters have been supported by The Texas Company, Humble Oil and Refining Company, The California Company, Tidewater Associated Oil Company, Phillips Petroleum Company, and Shell Oil Company.