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RADIATION EFFECT ON THE ADIABATIC COMPRESSIBILITY
OF LUBRICATING LIQUIDS

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Measurements of sound wave velocity and density in four irradiated lubricating liquids in the temperature range of 20°C - 30°C have been made.⁶⁰ The liquid samples were irradiated using a Co^{60} source. The experimental technique used to measure the sound velocity depends upon the measurement of the total phase shift of an ultrasonic wave through a known liquid path. From the measured velocity and density values adiabatic compressibilities have been calculated. It has been found that the adiabatic compressibility of four lubricating liquids decreases linearly with increasing radiation dose.

RADIATION EFFECT ON THE ADIABATIC COMPRESSIBILITY OF LUBRICATING LIQUIDS

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SUMMARY

Measurements of sound wave velocity and density in four irradiated lubricating liquids have been made. From the measured velocity and density values adiabatic compressibilities have been calculated.

INTRODUCTION

The advent of nuclear technology has added nuclear radiation to the list of environmental factors such as temperature, pressure, etc. under which lubricants must work. The effect of the nuclear radiation is very significant because lubricants vary a thousandfold in their ability to survive the effects of the nuclear radiation.

Although some studies on the radiation effect on several physical quantities of lubricating liquids (1, 2, 3, 4, 5) were reported in the literature, to our knowledge nothing dealing with the nuclear radiation effect on the adiabatic compressibility of liquids has been published.

In this work, at room temperatures, measurements of sound velocity and density in irradiated MS200 0.65 cSt, MS200 10 cSt, MS200 100 cSt, and Di-iso-butyl-phthalate have been made, and adiabatic compressibility values were calculated.

EXPERIMENTAL PROCEDURE

The adiabatic compressibility " β_s " values of liquids were calculated using the equation;

$$\beta_s = \frac{1}{\rho \cdot C^2} \quad (1)$$

where ρ , is the density, and C is the sound velocity in the liquid (6). The experimental technique used to measure the sound velocity depends upon the measurement of the total phase shift of an ultrasonic wave through a known liquid path (7). A short modulated pulse of high frequency is propagated through a known liquid path, the reflected pulse from a reflector is compared with a same frequency signal used a reference. By adjusting the frequency, signals may be made inphase and the sound velocity can be obtained in terms of the in-phase frequency, liquid path length and n , an integer which shows the number of sound wavelengths in the liquid path.

The densities of the liquids were measured by determining the weight of the liquid occupying a 10 cc Grade volumetric flask at the temperature of measurement.

b. Sound Velocity Measurement

Sound velocity measurements in the liquids in the temperature range of $20^{\circ} - 30^{\circ}$ have been made. The main uncertainty in the sound velocity measurements arises from the $\pm 0.1^{\circ}\text{C}$ error in the temperature determination which causes $\pm 0.035\%$ error in the velocity measurements. The error in the sound velocity which comes from the uncertainty in the liquid path is about $\pm 0.03\%$. The uncertainty coming from the radiation dose rate measurements is less than $\pm 0.004\%$. The error arising from the electronics system is negligible. Therefore sound velocity measurements were correct better than $\pm 0.07\%$.

It was found that velocity of sound decreases linearly with increasing radiation dose within the experimental error.

c. Density Measurement

Density measurements between 20° and 30°C were estimated to have an accuracy better than ± 0.01 per. cent. It was found that density, at small amounts of radiation increases linearly with radiation dose. The rate of this increase decreases with rising radiation.

d. Temperature Measurement

The temperature of the liquid was measured with a thermometer with 0.1°C divisions. This thermometer was calibrated by the Calibration Institute in Wertheim, and it is estimated that the temperature measurements are correct to within $\pm 0.1^{\circ}\text{C}$.

e. Irradiation Processes And The Irradiation Measurements

The liquid samples (approximately 50 cm^3) quantities were irradiated up to the "gel" point using a Co^{60} source in the Çekmece Nuclear Research Center. The samples rotated around the source planetarily and received a dose rate of 2900 Rad/min . Radiation dose rate was measured using a chemical dosimeter and it was estimated that radiation dose measurements are correct within $\pm 0.5\%$. Which causes less than $\pm 0.004\%$ uncertainty in the velocity measurements and less than, $\pm 0.002\%$ uncertainty in the density measurements.

CALCULATED ADIABATIC COMPRESSIBILITY VALUES

The calculated adiabatic compressibility values of the liquids are given in Table-1

The uncertainty in those values is less than $\pm 0.15\%$. The adiabatic compressibility of the silicone liquids decreases linearly with increasing radiation dose. The change in the adiabatic compressibility by temperature are not appreciably affected by radiation dose.

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Table 1. Calculated Adiabatic Compressibility Of The Liquids

Radiation Dose (M.Rad.)	$\beta_s \times 10^6 \text{ in}^2/\text{lb}$ Silicone MS 200 0.65 cSt.			$\beta_s \times 10^6 \text{ in}^2/\text{lb}$ Silicone MS200 10 cSt.			$\beta_s \times 10^6 \text{ in}^2/\text{lb}$ Silicone MS200 10 cSt.			$\beta_s \times 10^6 \text{ in}^2/\text{lb}$ Di-iso-butyl-phthalate		
	20°C	25°C	30°C	20°C	25°C	30°C	20°C	25°C	30°C	20°C	25°C	30°C
0	1.573	1.650	1.721	1.027	1.083	1.149	1.007	1.04	1.075	5.00	5.136	5.285
10	1.570	1.646	1.717	1.022	1.078	1.143	1.003	1.035	1.068	4.998	5.133	5.283
20	1.567	1.646	1.714	1.018	1.073	1.137	0.999	1.030	1.062	4.996	5.131	5.281
30	1.564	1.640	1.711	1.014	1.068	1.131	0.995	1.025	1.056	4.994	5.129	5.279
50	1.558	1.633	1.705	1.005	1.050	1.116	0.990			4.990	5.125	5.276
100	1.544	1.616	1.689	0.984	1.035	1.091				4.980	5.115	5.267
150	1.530	1.600	1.673	0.963	1.012	1.062				4.970	5.105	5.258
200	1.516	1.583	1.657							4.961	5.094	5.249
300	1.488	1.550	1.626							4.941	5.074	5.231
400	1.460	1.518	1.594							4.922	5.053	5.213
500	1.432	1.483	1.563							4.902	5.033	5.195
600	1.403	1.450	1.531									

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