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STUDIES ON THE NUCLEAR QUADRUPOLE RESONANCE OF IODINE I. THE EFFECT OF SURROUNDINGS OF NUCLEI UPON THE RESONANCE LINE

By

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1. Introduction

The nuclear quadrupole resonance of I^{127} in solid iodine has already been measured [1) 2) 3)] and also the resonance frequencies were reported as 332 Mc and 644 Mc at room temperature. The structure of the resonance line has also been studied [4)] precisely with a single crystal of iodine, and the complexity of the structure has been explained as a result of the electron–coupled spin–spin interaction.

In this paper, the spectrum of the nuclear quadrupole resonance of iodine nuclei in the surroundings of paraffin or sulfur was investigated in the solid state by using the mixtures of iodine and paraffin or sulfur in comparison with the pure crystalline iodine powder. The shift of resonance frequency of iodine nuclei in the different surroundings can not be observed. The width of the absorption lines of the mixture of iodine and sulfer was almost equal to that of the crystalline iodine, but the width of the absorption line of the mixture of iodine and paraffin seemed to be different from that of the crystalline iodine and is very narrow.

This result shows us that the nuclei of iodine in paraffin are oriented to a fixed direction as likely as in a single crystal of pure iodine.

2. Experimental Procedures

A block diagram of the apparatus is shown in Fig. 1. The detector used was a super–regenerative type with light-house tubes 2C40. The main frequency was modulated with a sinusoidal wave of 265 c/s by using the tuning-fork oscillator. And the main frequency was swept by changing capacity by the slow speed synchronous motor at the rate of 1 rph.

In order to examine the width and the shape of the resonance line, the method of narrow band amplifier and phase sensitive detector were used.

In these experiments, as a result of adopting the method of frequency modulation of small amplitude, the resonance line was recorded in the shape of derivative curve. All the samples were made by melting the mixture of pure iodine and pure paraffin or solid sulfur. The crystalline iodine was easily dissolved in a melted paraffin, and it was easily solidified by natural cooling.

At the same time, the solidified iodine sample from the melted state was also prepared for the comparison of the crystalline iodine, and of the other mixtures.

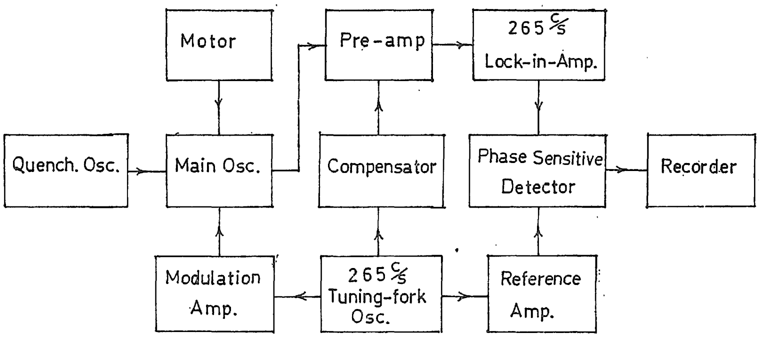

Fig. 1 Block diagram of apparatus.

These samples were packed into a small ampoule and was inserted to the radio-frequency coil of two turns which was mounted on the cold end of the Lechel's lines.

In our experiments, the following improvements were devised in order to separate the side band of the absorption line from the true line that the quenching frequency was selected as high as possible (260 kc/s) in spite of the most effective frequency for detecting sensitivity (192 kc/s) and the speed of the sweeping was also adjusted to considerably low (9 kc/ m) in order to obtain the fine details of the absorption curves.

3. Results of the Experiments

Derivative curves of the lower side of the absorption lines of iodine and its mixtures were respectively shown in Photos 1, 2, 3 and 4. These plates show the form of absorption lines obtained from the mixtures of iodine and paraffin, iodine and sulfur, solid iodine and crystalline iodine respectively. In these curves, the main frequency increases from right to left at the rate of 140 kc/m. All mixture samples were prepared by dissolving the weighed crystalline iodine into the fixt amount of the melted pure paraffin at the various ratios of mixing (from 5 weight percent to 20 weight percent iodine). The intensity of the absorption lines obtained from the above samples

Photo 1 The resonance curve of iodine nuclei in the mixture of iodine and paraffin.

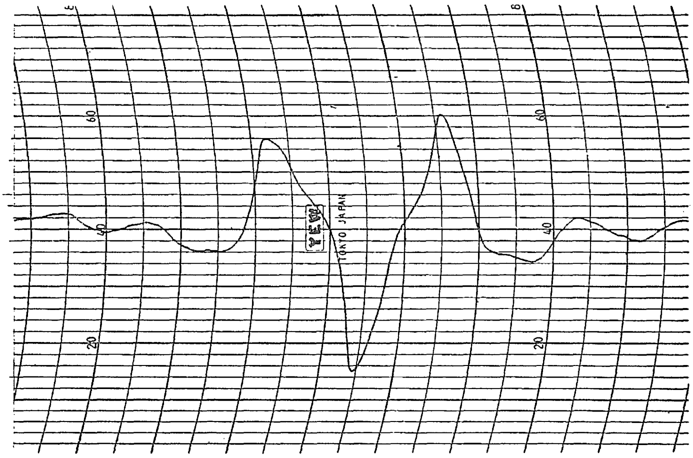

Photo 2 The resonance curve of iodine nuclei in the mixture of iodine and sulfur.

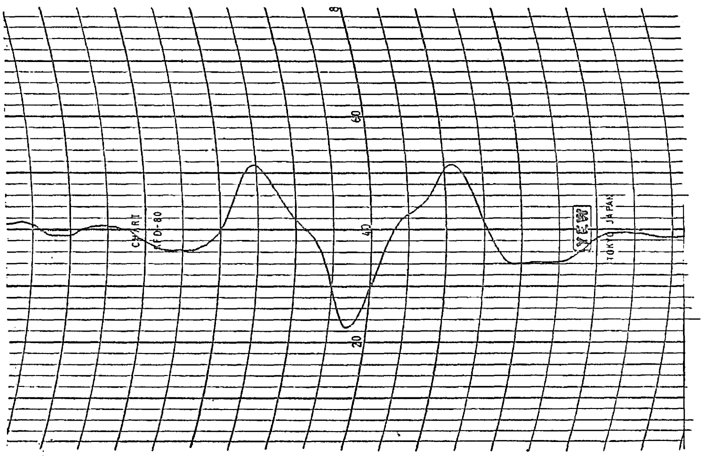

Photo 3 The resonance curve of iodine nuclei in the melted iodine (in the solid state).

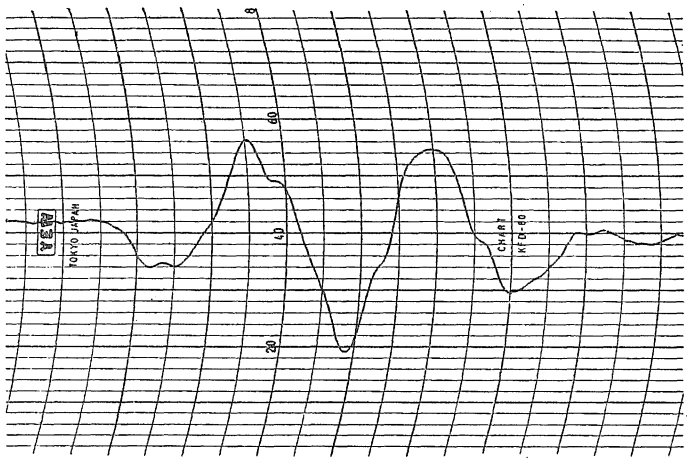

Photo 4 The resonance curve of iodine nuclei in the crystalline state.

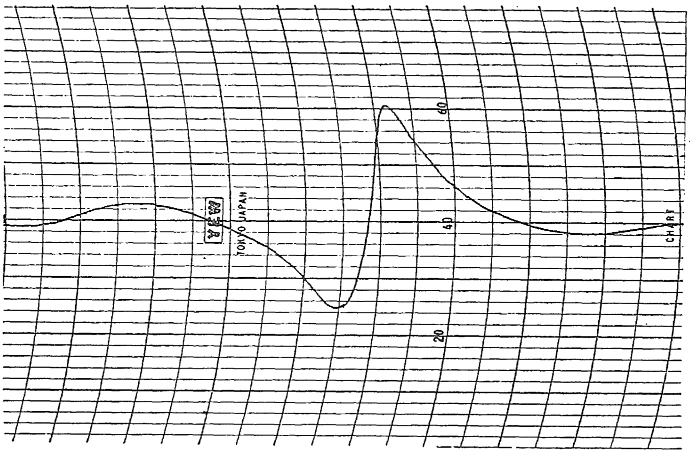

Photo 5 The resonance curve of wave meter.

increased with an expornential curve with increasing concentrations, but the shape of the lines is almost unchanged.

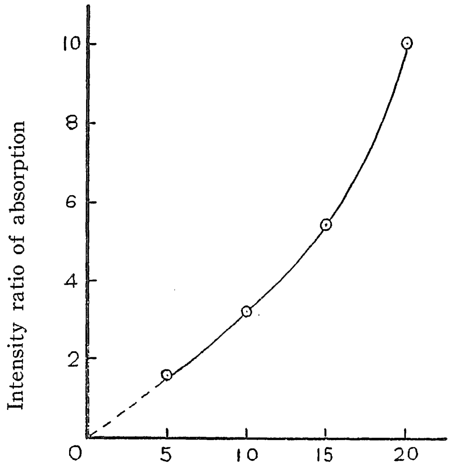

Fig. 2 Relation between the intensity and the concentration.

4. Discussion

As clearly shown in Photos 1−4, the shape of the absorption lines of the mixtures of iodine and paraffin was remarkably sharp and show a different patterns from the crystalline iodine or the mixture of iodine and sulfur. And this fact suggests us that the surroundings of iodine nuclei in solid paraffin may be considered as somewhat different from the others. If we assume that the surroundings of iodine nuclei in paraffin is identical to the single crystal of iodine, the shape of the absorption line should be changed [4] by rotating the sample in radio-frequency coil. However, such change was not observed. The details of the resonance curves in this experiments were shown in Photo 6. The main frequency was swept at the rate of 9 kc/m and the quenching frequency was adjusted to 260 kc/s in the above experiments. Photo 7 shows the representative microscopic pattern of the mixture of paraffin and iodine. In this plate the magnitude of crystalline iodine seems to be the order of micron in length, therefore the interaction between iodine nuclei and paraffin seems to be very little. In these microscopic observation of iodine crystallines in paraffin, it was found that a small crystalline iodine was connected to a fixed direction as a fine string and the above structure would give effect as likely on the absorption of the quadrupole resonance as in the single crystal of iodine.

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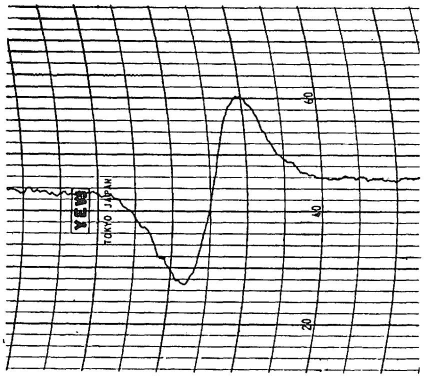

Photo 6 The details of the resonance curve of iodine nuclei in the mixture of iodine and paraffin.

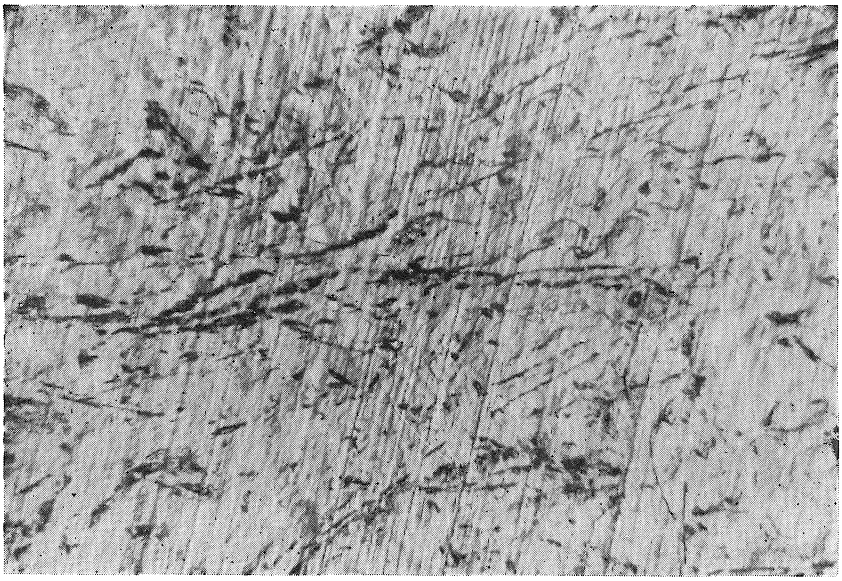

Photo 7 Microscopic pattern of the mixture of iodine and fused paraffin (in the solid state).

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