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Effect of Ultrasonic Irradiation on the Recovery of Uranium from Seawater with Adsorbents

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NOTE

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Ultrasonic irradiation is reported to promote chelate formation between metal ions and polymeric ligands in solution (*1*). It is expected that the recovery of uranium from seawater with adsorbents is affected by ultrasonic irradiation because this process is also based on chelation between the ligands of the adsorbent and uranyl ion in seawater. In the present note, adsorption of uranium from seawater was carried out under ultrasonic irradiation with an amidoxime-group-containing polymeric adsorbent.

About 40 mg of a fibrous adsorbent made by grafting acrylonitrile onto ethylene-tetrafluoroethylene copolymer fiber followed by amidoximating nitrile groups was conditioned with 100 mL potassium hydroxide 2.5% solution at 80°C for 15 min, then agitated in 2 L seawater at 25°C (*2*). The ultrasonic irradiation during adsorption was carried out with a Nippon Seiki sonicator, model NS 200-6U (frequency, 28 kHz; power, 200 W). Uranium was desorbed with 10 mL sulfuric acid (1 *N*) from the adsorbent and the amount was obtained optically. The solid line in Fig. 1 shows that the amount of uranium obtained in the absence of ultrasonic irradiation increases with the contact time. On the other hand, the amount in the presence of ultrasonic irradiation indicated by the dotted line continuously decreases with time. As a result, the amount of the latter obtained in 4 days is only 1/5 of the former, although the latter is a little larger than the former in the very initial period.

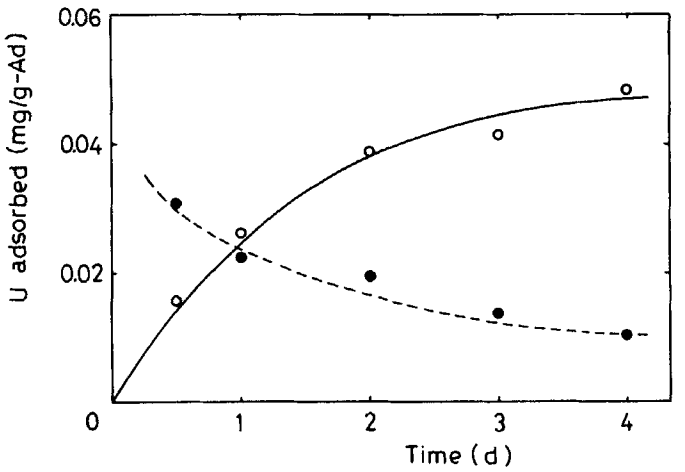

FIG. 1. Adsorption of uranium from seawater: (○) in the absence and (●) in the presence of ultrasonic irradiation.

It has been pointed out that ultrasonic irradiation brings about degradation of polymers (sonication) in solution (*3*, *4*). It is therefore probable that the present adsorbent fiber dipped in seawater is degraded by the ultrasonic irradiation during the adsorption. In order to check this possibility, electron microscopy was applied to the adsorbent which was irradiated in water for 1-3 days. As shown in Fig. 2, the surface of the adsorbent fiber became uneven and its diameter diminished with the progress of irradiation. This result clearly indicates that the adsorbent fiber is degraded by ultrasonic irradiation.

The degradation of the adsorbent was accompanied by the loss of functional groups from the adsorbent. Figure 3 shows the distribution curves of functional groups observed by electron probe x-ray microanalysis in the cross sections of (a) the original adsorbent fiber and (b) the adsorbent fiber irradiated in water for 3 days. Although the functional groups of both (a) and (b) locate homogeneously in the radial direction, the amount of the functional group [F.G.] of (b) is much smaller than that of (a). Considering that the amount of uranium adsorbed is proportional to [F.G.], it is concluded that the decrease in the amount obtained under ultrasonic irradiation, as shown in Fig. 1, is due to the loss of functional groups brought about by sonication.

The adsorbent kept in H_2O for 24 h was dipped in D_2O for the prescribed period, and the exchange rate of H_2O with D_2O was followed

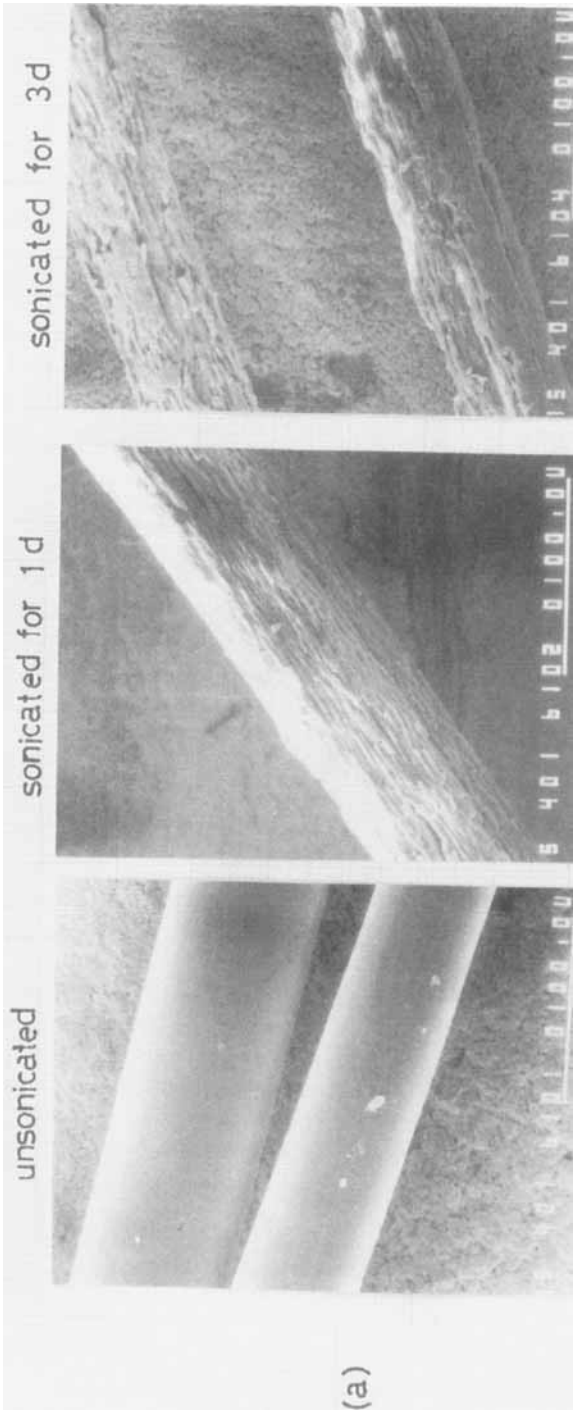

FIG. 2. Electron micrographs of the adsorbents irradiated for various periods: (a) outside view, (b) cross-sectional view. The white line indicates 100 μm. *(continued)*

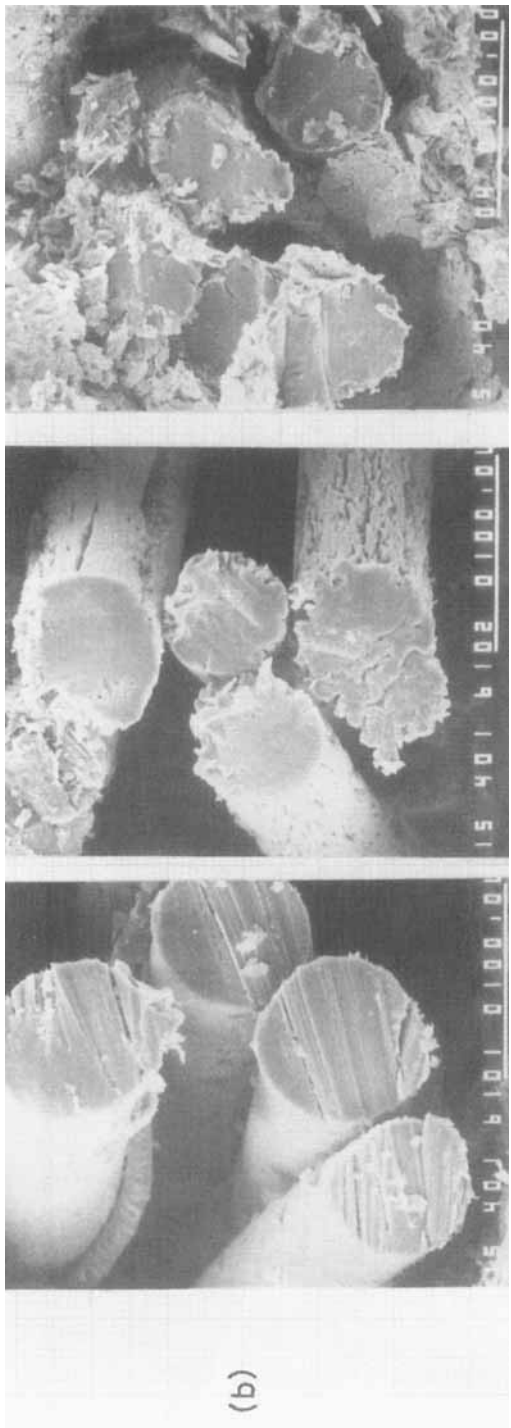

FIG. 2 (*continued*).

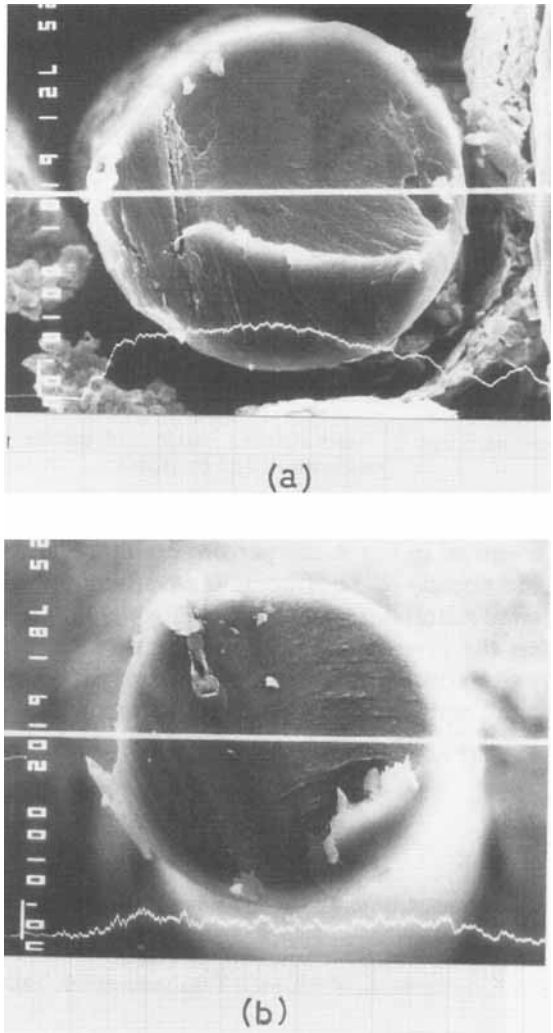

FIG. 3. Distribution of amidoxime groups in the cross section of the adsorbent observed by EPMA measurement: (a) unirradiated adsorbent, signal level: 500 cps; (b) adsorbent irradiated for 3 days, signal level: 250 cps.

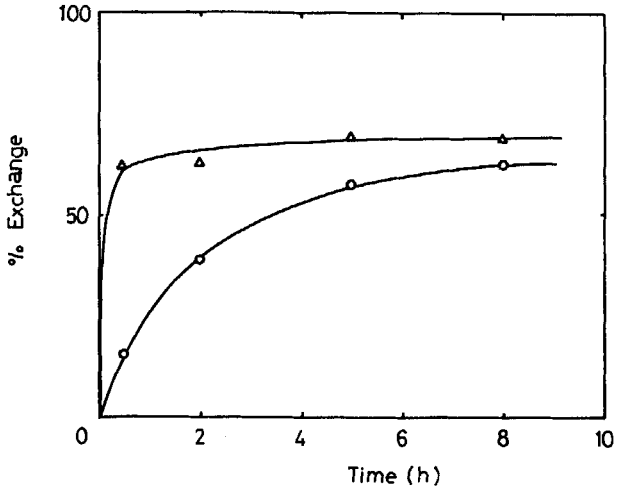

FIG. 4. Percent exchange of water between inside and outside the adsorbent: (○) unirradiated, (△) irradiated.

by NMR. As shown in Fig. 4, the percent exchange of water between the inside and the outside of the irradiated adsorbent is higher than that of the unirradiated adsorbent when the exchange period is short. This result indicates that the large amount of uranium in the very initial period obtained by the adsorbent in the presence of ultrasonic irradiation is partly due to the rapid supply of seawater which increases the probability of contact between the ligands in adsorbents and the uranyl ions in seawater.

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