POSTER

ELIMINATION OF COPPER ION FROM ITS DILUTE SOLUTION BY ACTIVATED CARBON FIBER UNDER APPLIED ELECTRICAL POTENTIALS

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Introduction

Activated carbon (AC) is a favorite material to treat waste water. Unfortunately, however, AC hardly adsorbs copper ion when it is simply soaked to its solution. Evidently concentration of the ion would be reduced, if AC is kept at a potential which is far more cathodic than equilibrium one calculated from the Nernst equation. This sort of elimination is, however, less suitable than that by adsorption, because copper in this case deposits in shape of fine grains, and they are so weakly bonded to the AC that they are easily detached and re-dissolved into the solution.

The reason why AC does not adsorb copper ion is not well established. A theory says that it is due to a positive surface charge caused by initially adsorbed ion. If so, it is implied that the adsorption might be materialized, if electrons are supplied at an appropriate rate to AC to neutralize the adsorbed ions and to let them migrate to the internal surface. Aimed at checking validity of this implication, an AC was dipped in a solution of acidic copper sulfate under cathodic potential of several levels.

Experimental

The employed solution was 0.002M aqueous solution of copper sulfate acidified to pH=0 by addition of sulfuric acid. Neither aeration, deaeration nor stirring was performed throughout experiments.

Strings of activated carbon fiber were disbonded from a cloth (code named as CWF 1500) which was fabricated by Toyo-Boseki Co. Its specific surface area is reported to be $1400m^2/g$. The string was connected to a lead wire through a copper terminal. Its electric resistance was approximately 52Ω. There was a distance of 20mm from the end of the connector to the surface of the solution in most of the experiments. Since exact value of electrical resistance of the string was difficult to determine, all data cited in this presentation are not corrected for it.

Results

1. Rest potential was approximately +450mV(against Ag/AgCl reference electrode in all cases).

2. Voltammetry was observed with a bundle of three strings dipped by 5mm in a solution of 500ml. The potential was shifted stepwise by 1mV every 2min from 440mV up to -250mV. The result is shown in Fig. 1. A shoulder is seen in the range more cathodic than -25mV.

3. Resistance of solution was calculated from the Cole-Cole plots observed on an identical bundle of three strings dipped by 5mm in a solution of 500ml at potentials of +100, 0, -100, -200 mV. The result revealed that the value at 0mV was almost identical with that at +100mV, while that at -100mV was larger than these, and that at -200mV was even larger(Fig.2).

4. Residual concentrations of copper ions after a bundle of 6 strings 35 mm in length was kept in a solution of 15ml at +100, 0, -100 and -200mV for 90hours were 128, 127, 4.54 and 0.10 ppm in weight, respectively (original concentration was 124ppm).

5. Crystals of copper were confirmed on the strings when the potential reached at -250mV in the experiment mentioned in term 2.

6. Crystals of copper were confirmed on the strings at the end of the whole experiment mentioned in term 3.

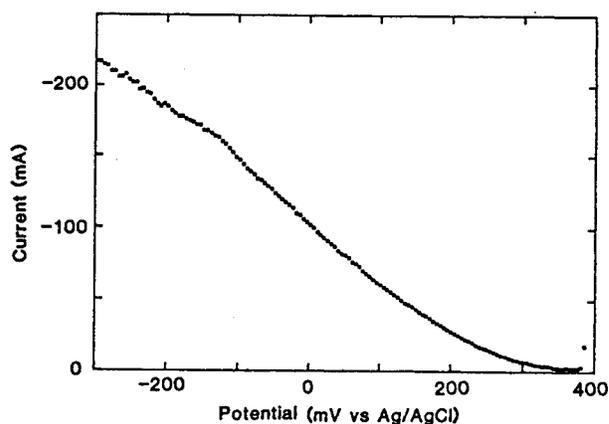7. In the experiments mentioned in term 4, copper

Fig. 1 Plots of current against potential

crystal were confirmed after the run at −200mV. At −100mV they disappeared at the end of the run, while they were there at some initial stage of the run. No crystal was confirmed at 0mV and at +100mV.

8. During the experiments mentioned in term 4, current decreased in the initial period, and then remained almost unchanged. The current at −200mV was larger than that at −100mV. At 0mV and +100mV, currents were small and varied chronologically in complex manners.

9. Chronological variations of Cole–Cole plots were observed at −200, −100, 0, +100mV. According to the results(Fig. 3), at −200mV and −100mV resistance of charge transfer slightly increased chronologically and resistance of solution increased in the initial periods and then became constant. These resistance were almost invariable at 0mV and +100mV.

Discussion

a. Based on the results mentioned in terms 2,3,4, it is considered that another reaction than that in the more anodic region starts to proceed and to eliminate copper ion from the solution at −25mV and beyond.

b. Based on the results mentioned in terms 5,6,7, it is considered that copper crystals may or may not deposit, or may deposit and then disappear at an identical potential.

c. Based on the result mentioned in term 8, it is considered that the rates of cathodic reaction at −200mV and −100mV fall at their initial periods and then they taper off and become constant. These variations of the current are
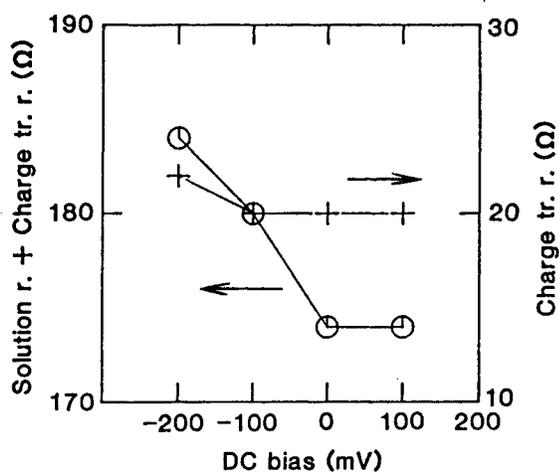
more due to a variation of concentration of chemical species in the solution than to a variation of a reaction mechanism on the surface of the electrode.

d. Based on the results on −100mV mentioned in terms 4 and 7, it is considered to be possible to eliminate copper ion from a solution not in crystalline copper but in a form of atoms adsorbed on the internal surface of AC.

e. The reason why crystalline copper once appeared on the surface of AC disappeared in later period, as was mentioned in term 7, is understood to be due to difference between the rate of electrodeposition of copper ion and that of its migration over the surface of AC. The former must heavily depends on its concentration in the solution, while the latter is likely far less so. When concentration of the ion in solution is large, i.e. in the initial stage of the run, ions deposit in a rate larger than that of migration. Then, excess of copper atoms would be temporarily stored on the surface of AC in the form of crystals.

Conclusions

It is concluded that AC can eliminate copper ion in the solution not in a form of crystalline copper, but in a form of atom adsorbed over internal surface of AC, when electrons are supplied to it at a potential appropriate to the concentration of the solution.

Fig. 2 Plots of charge transfer resistance and solution resistance against DC bias
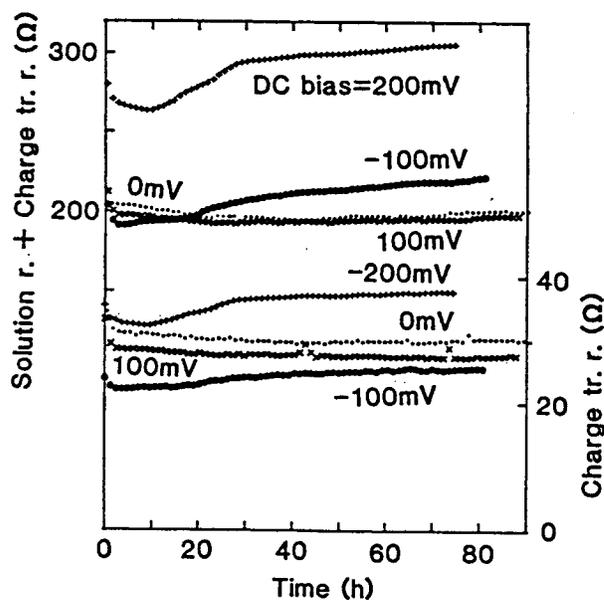

Fig. 3 Chronological variation of charge transfer resistance and solution resistance at various DC biases