

# ELECTRIC-DOUBLE-LAYER CAPACITANCE AND CHRONOLOGICAL VARIATION OF SODIUM CONTENT OF EX-LIGNIN FIBERS

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## Introduction

Since our previous study[1] suggested that a sodium-containing carbon fiber prepared from lignin would have electric capacity larger than the ordinary carbon fibers, electric capacitance was assessed for this type of carbon fibers in a wider range of sodium content in a wider range of bias potential by electrochemical impedance spectrometry (EIS).

## Experimental

The EIS was performed for two ex-lignin fibers, GLY containing 140 wtppm of Na and CLY containing 1.8 wt% of Na, in 0.5 M sulfuric acid at bias potentials between -100 mV through +1500 mV (vs. Ag/AgCl electrode).

## Results

In the case of GLY-fiber, the rest potential was ca +500

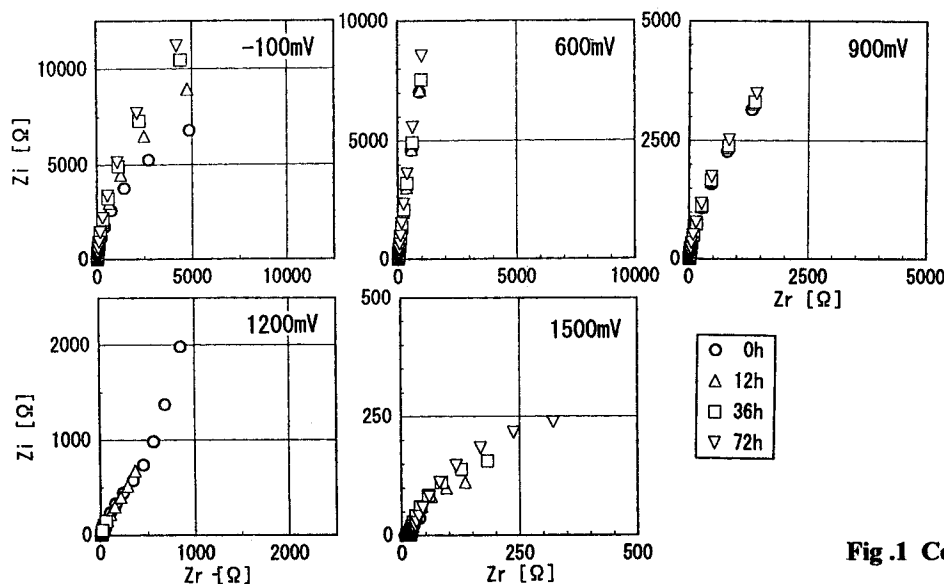


Fig.1 Cole-Cole plots of GLY fibers

mV and little varied with time. The Cole-Cole plots (Fig.1) were analyzed by the ordinary procedure. At or below +900 mV, the capacity, being  $30 \mu\text{F}/\text{cm}^2$  (for a unit external surface of the fiber), hardly depended either on the elapsed time or on the bias potential (Fig. 2). At +1200 mV, the capacity was almost comparable with it at the initial period, however, it increased to  $4300 \mu\text{F}/\text{cm}^2$  after 72 h. At +1500 mV, the value started at  $4000 \mu\text{F}/\text{cm}^2$  and decreased to  $300 \mu\text{F}/\text{cm}^2$  after 72 h. The larger capacity at deep anodic potentials might be caused by oxygen evolution due to electrolysis of water together with variation of the surface area of the fiber due to anodic oxidation.

In the case of CLY-fiber, the rest potential was ca. +400 mV and little varied with time. The Cole-Cole plots (Fig. 3) comprising three arcs (H-, M-, and L-arc from left to right) were analyzed by assuming the equivalent circuit shown in Fig. 4. The results are shown in Fig.5. The capacity of the L-arcs was  $7000 \mu\text{F}/\text{cm}^2$  at -100 mV

of the bias potential and decreased with increase in it, reaching  $440 \mu\text{F}/\text{cm}^2$  at +1200 mV. Except for +1500 mV, the values increased in the initial period and stayed almost constant after that. The fiber was consumed drastically at -100 mV and almost disappeared after 36 h. Based on our observation that the sodium atoms are eliminated from the fiber when it was soaked in the sulfuric acid (Fig. 6), we speculate that a possible reason for the capacity

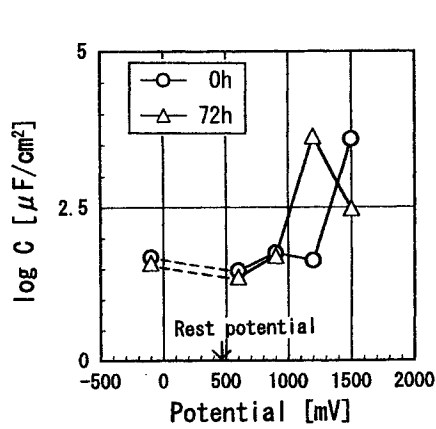


Fig. 2 Plots of capacity against bias potential for GLY fiber.

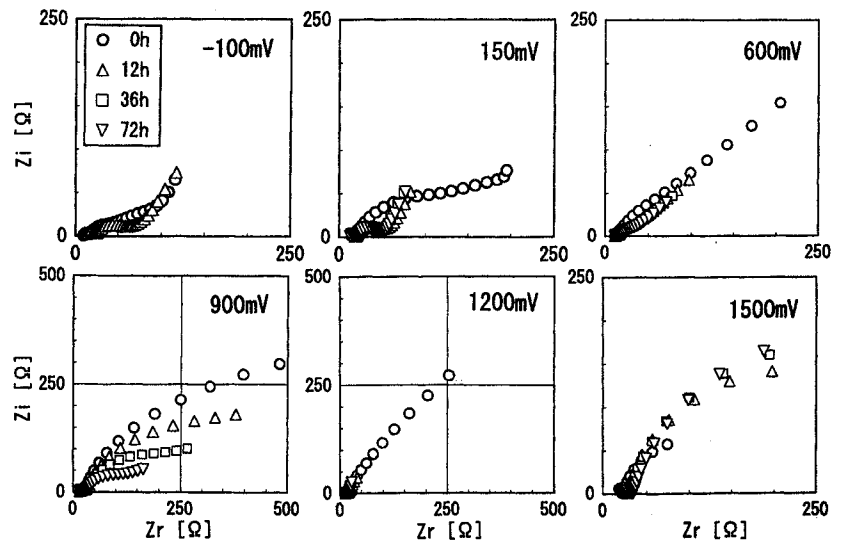


Fig. 3 Cole-cole plots for CLY fiber.

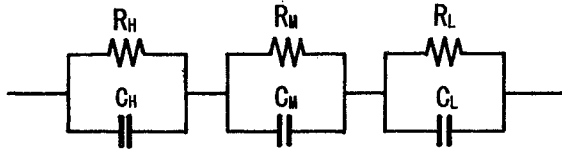


Fig. 4 (Left) Equivalent circuit used for analysis of CLY fiber.

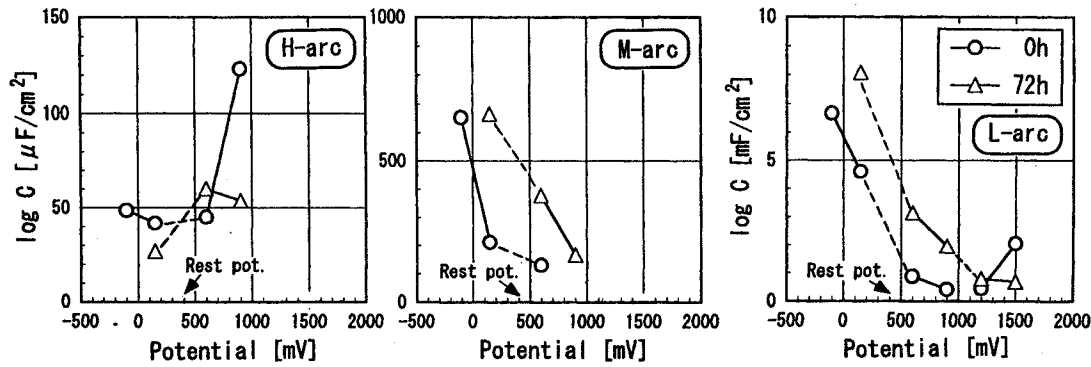


Fig. 5(Left) Plots of capacities against bias potential for CLY fiber.

increasing towards the cathodic potential might lie in the presence of sodium atom in the fiber. The sodium kations liberated from the fiber will stay long near the fiber due to its cathodic potential. This is virtually an increase in concentration of electrolyte in the vicinity of the fiber, which would result in increase in capacity [2].

### References

1. I. Timizuka et al: "Characterization of carbon fibers by EIS in sulfuric acid", *this extended abstract*.
2. D.C. Graham, *Chem Rev.*, 1947, 41, 441.

Fig. 6 (Right) Chronological variation of Na-content in CLY fiber.

