# Electrical conductivity of carbon or graphite felts

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Carbon (or graphite) felt is a material either used or proposed as porous anode and/or cathode in a few specific applications (metal recovery [1]; electroorganic synthesis [2]; $H_2O_2$ production for the chemical bleaching of pulp paper [3]). When used as a cathode in metal recovery, the electrical conductivity of the "metallized" felt is larger than that of the original felt.

The theoretical characterization of porous electrodes shows [4] that the apparent relative electrical conductivity $\gamma/\sigma$ of the two phases ($\gamma$ for the electrolyte in the pores; $\sigma$ for the solid matrix) is a parameter which influences the electrode potential distribution within the porous volume. The ratio $\gamma/\sigma$ has to be as small (i.e. the conductivity $\sigma$ as large) as possible in order to avoid the presence within the electrode volume a maximum or minimum potential, thus leading to a non satisfactory electrode design.. When graphite or carbon felt is used, e.g. as cathode in the electrochemical reduction of dissolved $O_2$ to $H_2O_2$ (for chemical pulp bleaching), the material is compressed.

The material has the following peculiarities:
*high porosity (99% if uncompressed material);
*compressibility which makes it difficult to reproduce a constant quality of electrodes upon replacement in the plant;
*electrical conduction through carbon/carbon or graphite/graphite contacts depends on the contact strength (known as the "microphone effect" [5]) . The felts are made of short, approximately 10 µm diameter fibers, and there are an exceedingly large number of fiber to fiber contacts. The overall electrical conduction pattern is complex, depending on the degree of compression.

It is, therefore, important to know what value of $\sigma$ can be obtained under a given compression in order to estimate the value of $\gamma/\sigma$ when ordinary electrolytes are used.

The apparent electrical conductivity of a dry RVG 4000 [ Le Carbone Lorraine] graphite felt was measured in air using the very simple set-up of Figure 1. The thickness , initially 1.2cm, was modified by loading the upper copper disc with different loads (up to 8kg). A d.c. electrical power supply served to measure V-I plots, from the slope of which $\sigma$ was computed by Ohm's law, which applies satisfactorily. The effect of the applied pressure on $\sigma$ is shown given in Table 1.

There is a rapid increase of $\sigma$ as the pressure is increased from small values, and a tendency to stabilize at higher pressures. $\sigma$ varies from 0.9 (uncompressed felt) to approximately 3 $ohm^{-1}m^{1}$ at higher pressures. Since the order of magnitude of $\gamma$ for common mineral electrolytes in volumes as porous as felts is 10 $ohm^{-1}m^{1}$ , the ratio $\gamma/\sigma$ could be between 10 (uncompressed felt) and 3 (moderated compressed felt) .

However, a value of $\gamma/\sigma \approx 10$ does not allow a monotonic electrode potential distribution [4]. Thus, caution is necessary when carbon (or graphite) felt is used as the active electrode in an industrial cell, particularly when the initial state of the felt is unchanged, and when the extent of the electrode potential distribution has to be restricted (selectivity criteria).

The value of $\gamma/\sigma \approx 10$ agrees with the value of the relative thermal conductivity, calculated from the data ($\approx$ 0.1 $W.m^{-1}\ °C^{-1}$ at 500°C) given by the supplier for the material thermal conductivity, and the thermal conductivity of water at 20°C ($\approx$ 0.6 $W.m^{-1}\ °C^{-1}$).

References:

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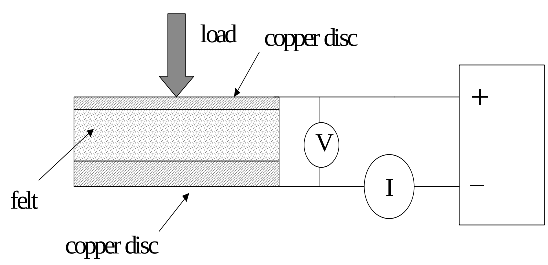


Figure1: Experimental set-up

| Load [kg] | Pressure [kg $m^{-2}$] | $\sigma$ [$ohm^{-1}\ m^{-1}$] |
|---|---|---|
| ≈ 0 | ≈ 0 | 0.87 |
| 0.5 | 76.4 | 2.11 |
| 1.5 | 203.7 | 2.73 |
| 2.5 | 331 | 3.07 |
| 4 | 522 | 2.63 |
| 8 | 1030 | 2.78 |

Table 1: Values of $\sigma$ for different loads