Global mass transport in the capillary gap cell

F. Cœuret[1] and T.Z. Fahidy[2]

[1] *Lab. Thermocinétique – UMR CNRS 6607 EPUN – B.P. 50609 – 44306 Nantes Cedex 3 (France)*
e-mail : francois.coeuret@polytech.univ-nantes.fr
[2] *Dept of Chemical Engineering, University of Waterloo, Waterloo, ON N2L3G1, Canada*
e-mail: tfahidy@engmail.uwaterloo.ca

Mass transport in divergent laminar radial flow between closely spaced parallel discs is important for the design of certain electrochemical cells such as the capillary gap cell [1]. A number of experimental mass transfer investigations have been discussed [2], while an approximate theoretical solution for high Schmidt numbers has been obtained for the local mass transport problem related to the hydrodynamics within the capillary gap cell [3].

The current authors have studied the problem at three different geometric scales in order to elucidate the scale effect, and to obtain experimental data for comparison with the approximate theoretical expression proposed by Dworak and Wendt.

By neglecting diffusion in directions others than *z*, a convective diffusion relationship was obtained theoretically for liquid – to - disc mass transport in the laminar permanent flow system of Figure 1, where the liquid flows at a volumetric rate Q_V. The relationship was derived by integrating the local expression of Dworak and Wendt, and it contains the following five dimensionless numbers:

$\overline{Sh} = \overline{k_d}\,(2a)/D$ or mean Sherwood number;

$Re = Q_V/(4\pi a \nu)$ or Reynolds number;

$Sc = \nu / D$ or Schmidt number;

R_2/R_1 and $2a/(R_2-R_1)$

is:

$$\overline{Sh} = 2.894\,\frac{(R_2/R_1)^{1/3}-1}{(R_2/R_1-1)^{1/3}}\left\{Re\,Sc\left(\frac{2a}{R_2-R_1}\right)^2\right\}^{1/3} \quad (1)$$

To the authors' knowledge, this relationship has not yet been tested by experimental results.

Three cells: A, B and C were used in the experiments. Except for the ratio R_2/R_1, the values of which differed very little among the cells, the dimensionless numbers *Re* and $2a/(R_2 - R_1)$ were varied to a large extent, as shown in Table 1; *Sc* had two distinct values. The liquid – to - disc mass transport coefficient was determined at three constant temperatures, using the classical electrochemical method [4] based on the reduction of potassium ferricyanide (0.005M) in aqueous NaOH (0.5N) containing potassium ferrocyanide (0.05M). As shown in Figure 2, there is good agreement between equation (1) and the experimental results; hence the validity of equation (1) is established for the design of cells, where the Reynolds number indicates a laminar flow regime (10 < Re < 4200).

References:
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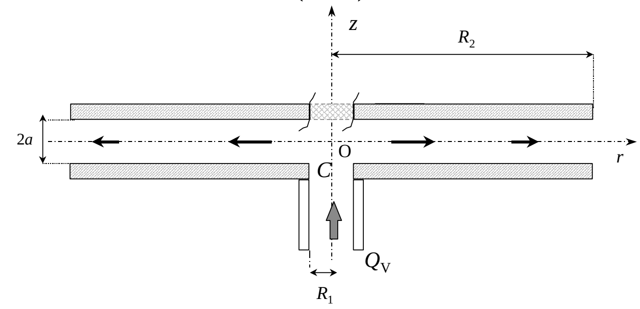

Figure 1: Schematic view of the electrochemical cells

	Cell A R_1 = 0.1cm R_2 = 2 cm	Cell B R_1 = 0.3 cm R_2= 4.5 cm	Cell C R_1 = 1 cm R_2 = 245 cm
R_2/R_1	20	15	25
2*a* [cm]	0.05; 0.1; 0.15	0.1; 0.16	0.2; 0.3; 0.5
$2a/(R_2 - R_1)$	0.026 to 0.079	0.024 0.038	0.0083 to 0.021
Re	10 to 360	16 to 1340	20 to 4200
Sc	1900	1900	1220

Table 1: Values of the parameters

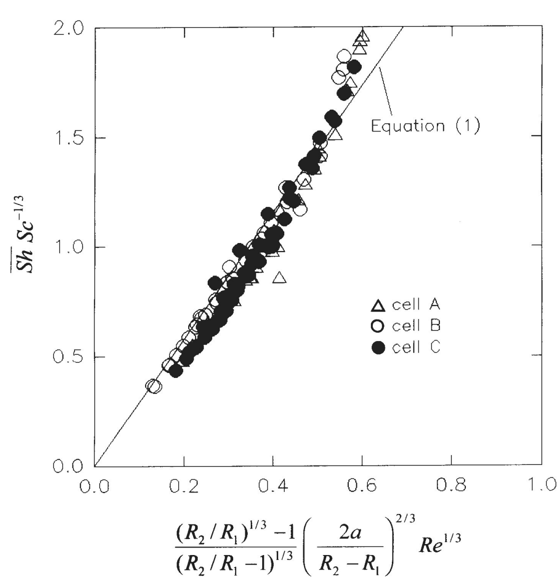

Figure 2: Comparaison de l'équation (1) à l'expérience