MASS TRANSFER CAUSED BY GRAVITATIONAL INSTABILITY AT REACTIVE SOLID-LIQUID INTERFACES

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KEYWORDS:

Main subjects: mass transfer, convective flow, porous media
Fluid: gravitational instability, miscible fluids
Visualization method(s): infrared absorption
Other keywords: reactive solid-liquid interface, surface geometry

ABSTRACT: Mass transfer in porous media has been of interest to a number of researchers in the field of engineering. The transfer of substances is generally attributed to diffusion, convection of pore fluid and, in some cases, reaction with surfaces of porous media. It is difficult to understand owing to the great sensitivity to ambient conditions such as gravity, boundary geometry and fluid properties. In this study, we investigated mass transfer by gravitational convection with reaction at the surface of porous media.

Mass transfer in porous media was demonstrated by means of electrochemical deposition experiment on particulate beds with complex structures. A copper plate (anode) and a stainless steel particulate bed (cathode) were placed at the upper and bottom side of a thin vertical cell which was filled with copper sulfate solution. After the application of electricity, cupric ion is provided from the copper plate to the solution, transported by fluid convection, and then consumed at the particulate bed. We observed convection flow and transport behavior of ions between the electrodes.

The convective behavior of ion was visualized by utilizing the infrared absorption characteristics of cupric ion [1]. We observed gravitational instability and convection flow due to concentration gradient of ions in opposite direction to that of gravity, which is formed by reaction at solid-liquid interfaces. The experimental cell and the visualized images are shown in Fig. 1. In the case of flat interfaces (upper interfaces in Fig. 1), the finger-like convection similar to Rayleigh-Taylor instability was observed [2]. On the other hand, the convection generated from complex-shaped interfaces (lower interfaces) was greatly dependent on their geometry. These results suggest that the resultant convective flow is closely related to the reactive interface geometry.

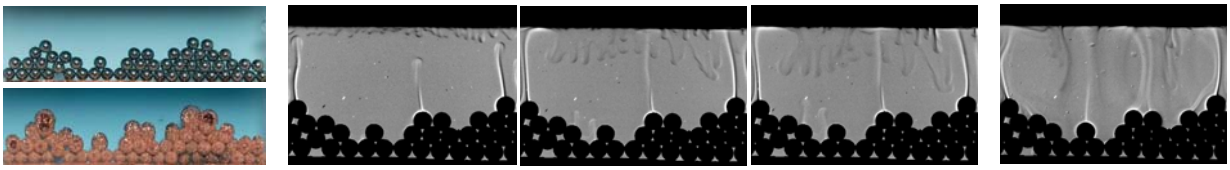

Fig. 1 Experimental cell before and after the depositions (left), visualized images of cupric ion behavior caused by gravitational instability at t = 13s, 19s, 22s (centre), and steady convective flow (right).

References

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