The effects of molecular orientation and heavy oil contamination on the CO_2 transfer across the air-water interface

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It is of great importance to accurately estimate the CO_2 exchange rate across the air-sea interface in predicting the global warming problem. This estimation is also closely related to the development and efficiency evaluation of a CO_2 immobilization technique using the coral or algae, which has been promoted by various research institutes. In addition, the effects of surface pollutions by the heavy oil run off by a ship accident and leaked from the coastal zone on the ecosystem have been considered, but the effects on the CO_2 exchange rate between atmosphere and ocean have not been discussed.

The purpose of this study is, therefore, to physically explain the reason of the difference in the CO_2 exchange rate between fresh water and sea water and to investigate the effects of surface pollution by heavy oil on the exchange rate. The CO_2 absorption experiments were conducted in an oscillating-grid tank with the gas-liquid interface for three cases; the electrolytic solutions of NaCl, $MgCl_2$ and $MgSO_4$, the fresh water with pulsating electric field, the fresh water contaminated by heavy oil.

The results show that the mass transfer coefficients for sea water and salt water with the same salinity as in the sea water decrease to 50% of the coefficient for fresh water, and that the damping effect on the mass transfer coefficient is completely the same for other electrolytic solutions of $MgCl_2$ and $MgSO_4$ despite the difference in ionic strength. The cause of the damping is not due to the molecular orientation of electrolytic solution at the gas-liquid interface, but it is due to tiny and invisible surface impurities (surface activity materials). In short, the molecular diffusion at the interface is reduced by the appearance of the surface impurities and therefore the decrease of the effective molecular diffusivity amplifies the difference of about 5% in the molecular diffusivities between electrolytic solution and fresh water, which causes the big difference in the mass transfer coefficients. In addition, it is found that the mass transfer coefficient for the interface contaminated by the little heavy oil decreases to the value of 30% for the clean interface.