Concentration Boundary Layer Thickness Decrease Mechanism Analysis under Magnetic Field Imposition through Cu^{2+} Concentration Time Variation

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1. Introduction

For solid-liquid chemical reactions, mass transfer is often the rate determining step. Therefore, agitation of bulk liquid has been used for the enhancement of mass transfer rate [1]. However, as concentration boundary layer is in the velocity boundary layer, by using such macroscopic agitation methods, decrease of the concentration boundary layer thickness is limited. Therefore, a new method, direct excitation of force in the vicinity of solid-liquid interface has been proposed [2]. In this method, the concentration boundary layer formed by dissolving solid copper from anode into aqueous solution, and it's thickness in the whole vicinity area of the anode decreased when imposing a static magnetic field and a DC current simultaneously compared to that only the DC current was imposed. Two potential mechanisms for concentration boundary layer thickness decrease were proposed: convection or hydrodynamic instability [3]. This research aims to analyze whether convection and/or hydrodynamic instability are the concentration boundary layer thickness decrease mechanism or not through measuring Cu^{2+} concentration time variation by comparing the two cases with or without magnetic field.

2. Experimental method

The experimental apparatus was designed based on the past research [2]. A 10mm height transparent vessel was filled with 0.3mol/L $CuSO_4$+0.1mol/L H_2SO_4 aqueous solution. Two parallel 20mm length Cu electrodes were set in the upper and lower parts of a 10mm height transparent vessel, with the upper one cathode, and lower one anode. Two 5mm length insulators covered the left and right sides of the lower Cu electrode. Two experimental patterns composed (1) Only the DC current imposition and (2) Only the DC current imposition, 30s and followed by simultaneous imposition of the DC current and the static magnetic field, 30s. Through imposing the current, the concentration boundary layer formed due to the dissolution of solid Cu into the solution. And liquid motion parallel to the anode was excited when the magnetic field was imposed. According to Lambert-Beer's Law, the Cu^{2+} concentration is related with the solution brightness, the Cu^{2+} concentration can be directly calculated by measuring liquid brightness. The Cu^{2+} concentration was measured in the vertical direction 88μm away in the middle part of the anode.

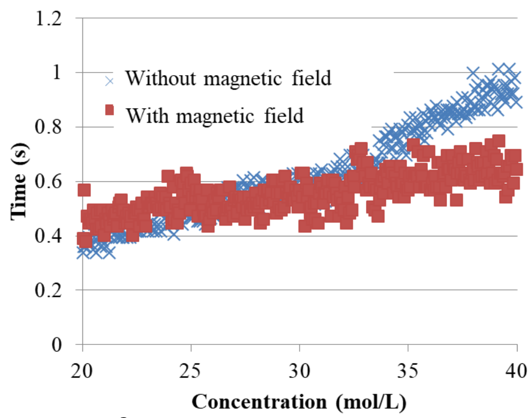

Fig.1 Cu^{2+} concentration time variation curve

3. Experimental results

Fig.1 indicates the Cu^{2+} concentration time variation results under the two experimental conditions. The Cu^{2+} concentration in the both experimental conditions were same until 30seconds. In the case without the magnetic field it continuously increased while it only slightly increased in the case with the magnetic field. If the hydrodynamic instability occurs, increase in Cu^{2+} concentration and its decrease should be observed. Therefore, in this experimental condition, hydrodynamic instability was not excited, and the convection is one of the candidate mechanisms for the concentration boundary layer decrease.

References

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