Experimental Thermal and Fluid Science 35 (2011) 558–564

Contents lists available at ScienceDirect

Experimental Thermal and Fluid Science

journal homepage: www.elsevier.com/locate/etfs

Effect of suspended CuO nanoparticles on mass transfer to a rotating disc electrode

O.N. Sara [a,*], F. İçer [a], S. Yapici [a], B. Sahin [b]

[a] Department of Chemical Engineering, Faculty of Engineering, Atatürk University, 25240 Erzurum, Turkey
[b] Department of Mechanical Engineering, Faculty of Engineering, Atatürk University, 25240 Erzurum, Turkey

ARTICLE INFO

Article history:
Received 26 August 2010
Received in revised form 15 December 2010
Accepted 16 December 2010
Available online 23 December 2010

Keywords:
Nanofluid
Mass transfer
Rotating disc
Electrochemical limiting diffusion current

ABSTRACT

The effect of suspended CuO nanoparticles on the mass transfer to a rotating disc electrode was investigated experimentally, using the electrochemical limiting diffusion current technique. The particle volume fraction was from 0.39% to 1.94%. The rotating speed ranged from 100 to 1000 rpm, which yielded the Reynolds number between 10 and 110, based on the electrochemically active disc radius. The results showed that the addition of the suspended particles increased the limiting current and the plot of log I vs. log ω resulted in linear lines, of which slopes decreased with increasing particle volume fraction. The ratio of Sh/Sh_o ranged from 1 to 1.5. The Sherwood number correlation as function of the Reynolds number and the particle volume fraction was also given.

1. Introduction

Heat/mass transfer rates encountered in various processes can be enhanced employing different techniques, which are called as the heat/mass transfer enhancement. For the systems with liquid as working fluid, the addition of solid particles to the liquid is one of these methods [1]. Many researchers have investigated the addition of solid particles on the mass transfer rate. In these works, a combination of the rotating disc electrode (RDE) and the electrochemical limiting diffusion current technique (ELDCT) has been widely used [2–6]. Particle materials, such as Al_2O_3, SiC, B_4C, $CaCO_3$, glass, polymer, etc. have been used for this purpose. The solid volume fractions up to 40%, and rotating speeds up to 5000 rpm have been employed in these works. For the mechanisms of the effect of the particle addition into the working liquid, there are three different explanation; hydrodynamics, diffusion and blockage of active surface by solid particles. The first two enhance mass transfer rate, while the last one decrease it [4].

Sonneveld et al. [3] carried out an experimental investigation for the effect of SiC (3–85 μm) particles on the mass transfer to a RDE system. They explained the increase in the mass transfer by the rotation of the particles in the diffusion boundary layer, resulting in a thinning in the boundary layer. It was reported that there is a critical value for both the particle volume ratio and rotating speed to affect the mass transfer. The reason for the critical value of the volume ratio was attributed to the gravitational effect, and it was reported that the critical rotation speed was inversely proportional to the particle size.

Anderson et al. [2] performed an experimental work to determine the effect of solid particles on the mass transfer using RDE and ELDCT with suspended glass and polymer particles (1–100 μm). They explained the enhancement in the mass transfer by two different mechanisms, depending on particle size. For the situations where the particle diameter was equal to or smaller than the concentration boundary layer thickness, the increase in the mass transfer was originated from the micro convective vortices. When the particle diameter was larger than the boundary layer, the enhancement was originated from a different mechanism, involving the formation of particle-free wall layer.

Marie de Fricquelmont-Loizos et al. [5] and Caprani et al. [4] performed an experimental and theoretical work for the mass transfer in RDE system with particles. They used Al_2O_3, SiC, and B_4C particles, with the diameter between 0.3 and 40 μm, the rotation speed in the range of 20–6000 rpm. They investigated the effect of the parameters, such as disc diameter, surface roughness, liquid viscosity, temperature, and particle volume fraction on the behaviour of the limiting current. They found that, for the solution without inert particles, the plot of log I (electrical current) vs. log ω (rotation speed) resulted in a linear line with one slope in whole range of rotation speed. However, for the solution with suspended particles, this linear line had different slopes in the range of the rotation speed of RDE. The slope changed from 2 to 4 depending on the investigated parameters such as particle size, viscosity, particle volume fraction, etc. In this work, the effect of the parameters on the limiting diffusion current was only given; no mass transfer results or correlation was submitted.

* Corresponding author.
E-mail addresses: onurisara@karatekin.edu.tr, onuri@rocketmail.com (O.N. Sara).

0894-1777/$ - see front matter © 2010 Elsevier Inc. All rights reserved.
doi:10.1016/j.expthermflusci.2010.12.011