Chemical Engineering Journal 219 (2013) 118–123

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Electrohydrodynamic (EHD) mixing of two miscible dielectric liquids

M. Jalaal [a,*], B. Khorshidi [b], E. Esmaeilzadeh [b]

[a] School of Engineering, University of British Columbia, Kelowna, BC, Canada V1V 1V7
[b] Department of Mechanical Engineering, University of Tabriz, Tabriz 51666, Iran

HIGHLIGHTS

- A novel electrohydrodynamic mixer is presented.
- The efficiency of the mixers is studied using image processing.
- No moving part is used in the current mixer.
- The mixer can be used in a wide range of applications, from pharmaceutical to petroleum processes.

ARTICLE INFO

Article history:
Received 8 October 2010
Received in revised form 30 September 2012
Accepted 1 October 2012
Available online 10 November 2012

Keywords:
Electrohydrodynamics
Mixing
High voltage electric field
EHD Mixers

ABSTRACT

A novel method is presented for mixing of two miscible dielectric liquids using D.C. electric field where Electrohydrodynamic (EHD) forces are used to increase the interface instability and fluids circulations in an enclosure, resulting to rapid dispersion of phases. Experiments were provided for a range of electrical potential (from 0 to 30 kV) and a Digital CCD camera is used to record the experimental observations. Results are analyzed, processing the images based on color intensities. The experimental results show that employing electric field is effective in providing a force able to cause instability on liquid–liquid interface and generate internal flows, significantly increasing the efficiency of mixing for the liquid–liquid system. The current results assist to step forward in design of EHD mixers, which are noteworthy, since they contain no moving parts and are relatively easy to integrate in relevant systems during fabrication.

1. Introduction

Mixing is on of the most demanding operations in several industries such as chemical, pharmaceutical and food processing. In pharmaceutical units and small-scale fluidic systems, often objective is rapid mixing of two initially segregated liquid layers in minimal amount of space. Therefore, any effective method to enhance rate of mixing of the fluids can lead to higher efficient functionary of these systems and units. For this purpose, several passive and active techniques via experimental and theoretical studies are proposed for micro and macro scales [1–4]. One category of these methods that employs flow induced by EHD phenomena, has gained significant attention during the last decades and showed a great promise of mixing due to the fact that any disturbance induced by electric field can help mixing process [5–10].

A detailed description on dynamics of liquid–liquid interfaces under the influence of electric field can be found in Taylor and McEwan [11], who obtained a large body of experimental data confirming the fundamentals of the theory of electrohydrodynamic instability. Melcher and Smith [12] conducted a detailed analytical investigation of the small amplitude motions of a plane interface between two fluids stressed by an initially perpendicular electric field. In the model, the influence of viscosity on instability growth rates in the zero-shear stress limits of perfectly conducting and perfectly insulating interface was described. Recently, Eow and Ghadiri [13] investigated the behavior of water–oil interface, measuring the electric current. They concluded that the turning point of the voltage–current characteristic curve is due to formation of a liquid cone at the liquid–liquid interface.

DePaoli et al. [14] presented a liquid-phase approach for particle production using EHD mixing. Their experimental results confirmed that the reactors utilizing EHD mixing could be used for continuous, rapid production of homogenous, ultrafine particles. Shankar and Sharma [15] analytically studied the effect of an externally electric field on the stability of the interface between two thin leaky dielectric fluid films using a linear stability analysis in long-wave limit. The results showed that the viscosity ratio, μ_r, has a significant effect on dynamics of the interface between two leaky dielectrics. Moreover, the presence of nonzero conductivity

* Corresponding author.
E-mail addresses: maziyar.jalaal@ubc.ca, m_jalaal@yahoo.com (M. Jalaal).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.10.062