Study On Electrostatic Extrusion Method For Synthesizing Calcium Alginate Encapsulated Iron Oxide

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Abstract

Electrostatic extrusion method is used to produce polymer beads by dripping polymer mixtures into hardening solution using syringing system with electrostatic charges. Through this method, iron oxide particles can be encapsulated into calcium alginate polymer beads. The changes in characteristics of the produced bead can be observed through changing the physical parameter values of applied voltage, height of electrodes, flow rate, and needle sizes of the system. From experimental study using Response Surface Methodology (RSM) modeling, the diameter of produced beads significantly decreases when applied voltage increases and needle size decreases. The optimum parameters from RSM is determined as 4kV applied voltage, 2cm of electrodes height and 0.4mm of needle diameter while flow rate does not contribute significant effect on the system. Furthermore, instrumental and analytical studies are carried out to characterize the produced bead based on the bead sizes, sphericity, surface area and surface morphology. Other than that, a mathematical model is developed from basic equations related to the system on production of calcium alginate encapsulated iron oxide. The model is then improvised and validated via experiment and it shows good agreement with the experiment result where error of the models is 0.4% for bead diameter and 2.5% for bead sphericity.

Keywords: *polymer beads, RSM, electrostatic extrusion, encapsulation, modeling and simulation*

1. Introduction

Electrostatic extrusion method is one of the methods to fabricate encapsulated multifunctional components such as adsorbent for water and waste water treatment [1]-[3]. Droplet extrusion allows the encapsulation of components into polymer beads, producing multicomponent beads. By applying electrostatic forces on to the droplet extrusion needle, the extrusion performance can be increased [3]-[4]. An electrostatic extrusion system is a system with needle setup and applied with electrostatic charge as in Figure 1 [3]-[5]. In this study, sodium alginate and iron oxide mixture as polymer liquid is dripped through the needle with applied electrostatic charge into the hardening solutions, calcium chloride. Voltage difference is applied between the needle and electrode plate beneath the hardening solution to create electrostatic forces during the dripping process.

Several researches carried out electrostatic extrusion encapsulation using optimized parameters settings through trial and error to obtain desired extrusion products [3]-[4],[6]-[8]. The alginate beads produced are affected by concentration of the alginate solutions and flow rate [4]. Other researchers reported that voltage and needle sizes of the extrusion system affects the characteristic of the produced beads [3],[6]. Other operating parameters of the bead extrusion are flow rate and electrode distances of the system [4], [6], [9]. However, in order to obtain the direct relationship of the operating parameters

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