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Original Research Paper

Effect of concentration and temperature on the properties of the microspheres prepared using an emulsion–solvent extraction process

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ABSTRACT

Methylaluminoaxane (MAO) microspheres of average size smaller than 100 μm were prepared using a solvent extraction process; excess of perfluorocarbon (PFC) was added to the hydrocarbon-in-perfluorocarbon emulsion to solidify the MAO droplets. The effect of the MAO concentration in the dispersed phase, the temperature of the PFC added to the emulsion and the preparation temperature on the size, the size distribution and the morphology of the MAO microspheres was studied. MAO droplets broke up more easily with decreasing dispersed phase viscosity and hence the size of the MAO microspheres decreased. The temperature of the PFC added to the emulsion did not significantly affect the size and the morphology of the MAO microspheres. The size of the MAO microspheres increased with increasing preparation temperature. The main reason for the increased size of the MAO microspheres was the increased coalescence with increasing preparation temperature. In addition the porosity of the MAO microspheres increased with increasing preparation temperature.

1. Introduction

Microspheres are widely used in different applications such as the controlled release of drugs, cosmetics, inks, pigments and chemical reagents. An emulsification–solvent extraction/evaporation process is one possible method to produce the microspheres. The control of the microsphere preparation processes is essential to produce a desired mean size of the microspheres, size distribution and morphology of the microspheres. Freitas et al. [1] and Li et al. [2] have written recent reviews about the microsphere preparation using emulsification–solvent extraction/evaporation processes.

The solubility properties of the compounds of the microspheres are important parameters when selecting the emulsion phases for a microsphere preparation process. A low solubility of the compounds in the continuous phase is required for obtaining a high yield. Perfluorocarbons are non-solvents to most compounds, have partial miscibility with hydrocarbons and also are chemically inert. Therefore, perfluorocarbons are very well suitable to be used as the continuous phase in an emulsification–solvent extraction process.

1.1. Effect of preparation temperature on the microsphere properties

The microsphere preparation temperature significantly affects the microsphere properties. The average microsphere size has been shown to increase with increasing preparation temperature [3,4]. However, Yang et al. [5] reported the opposite result. An increase in the preparation temperature from 4 to 29 °C led to a decrease in the microsphere size but at high preparation temperatures (above 29 °C) the size of the microspheres increased. The microsphere size distribution has been shown to widen with increasing preparation temperature [3,4].

The preparation temperature has been shown to have an effect on the microsphere morphology. At low preparation temperature, non-spherical particles were produced whereas an increase in the preparation temperature gradually improved the sphericity of the microspheres [3].

1.2. Factors affecting the porosity of the microspheres

The porosity can be a desired property of the microspheres. For example, by increasing the porosity the degradation rate of the microsphere increases and therefore the drug release rate can be increased. The porosity of the microspheres can be adjusted for example by adding a non-solvent, which does not dissolve the matrix material, in the dispersed phase [6,7]. Porous microspheres can also be produced using a multiple emulsion solvent extraction/evaporation method [4,5,7–13]. It is also possible to produce porous microspheres by adding a gas evolving chemical to the inner emulsion phase [14]. The surface porosity of the microspheres has been shown to increase at preparation temperatures close to the boiling point of the dispersed phase solvent [15].

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