Iran Polym J (2012) 21:289–296
DOI 10.1007/s13726-012-0034-1

ORIGINAL PAPER

Preparation and properties of soapless poly(styrene–butyl acrylate–acrylic acid)/SiO_2 composite emulsion

Fa-Ai Zhang · Jian-Shu Kang · Ming Luo · Cai-Li Yu

Received: 1 September 2011 / Accepted: 1 February 2012 / Published online: 20 March 2012

Abstract Soapless emulsion polymerization of styrene-butyl acrylate-acrylic acid was carried out using single or combined polymerizable emulsifiers, such as hydroxypropyl methacrylate sodium sulfate (HPMAS), sodium vinyl sulfate, and vinyl alkylphenol polyether sulfates (NRS-10), in the presence of colloidal nano-SiO_2 solution in order to obtain films with high degree of hardness and water-resistance. Monomer conversion, formation of coagulum, viscosity, particle size, size distribution, and surface tension of the emulsions, as well as the film properties, were determined and compared with those of an emulsion prepared with the conventional emulsifier sodium dodecyl sulfate and polyoxyethylene octylphenol ether. Emulsions prepared from a mixture of two polymerizable emulsifiers NRS-10 and HPMAS (1:1, weight ratio) have presented high monomer conversion, low coagulum, and small particle sizes. When the emulsifier level increased within a certain level, the monomer conversion increased but particles size decreased. Increased amounts of reactive emulsifiers led to low monomer conversion, large amount of coagulum and small particle sizes. With the increase of nano-SiO_2 the particle sizes and the viscosity of the emulsion also increased. The introduction of reactive emulsifiers improved the water-resistance of the resulting films, and the addition of nano-SiO_2 increased the hardness of the coatings. Under optimal conditions, the coatings made from emulsions produced from a combination of reactive emulsifiers such as NRS-10 and HPMAS (1:1, weight ratio) at 2 % level (based on monomer weight) exhibited remarkable hardness, adhesion force and water-resistance.

F.-A. Zhang (✉) · J.-S. Kang · M. Luo · C.-L. Yu
Key Laboratory of Nonferrous Materials and New Processing Technology, Ministry of Education, College of Material Science and Engineering, Guilin University of Technology, Guilin 541004, People's Republic of China
e-mail: zhangfaai@163.com

Keywords Styrene-acrylate emulsion · Polymerizable emulsifier · Nano-SiO_2 colloid · Hardness · Water-resistance

Introduction

Emulsion polymerization is a method that is widely used in the production of water-based resins, coatings, adhesives, synthetic rubbers, thermoplastics, binders, rheological modifiers, hollow pigment, polymer microspheres, and drug delivery [1]. For example, poly(styrene-acrylate) emulsion is prepared by emulsion polymerization, which is a well known film-forming material for architectural coatings. Semi-continuous polymerization is the most frequently used process for preparing styrene-acrylate copolymer emulsions. Over the past decades, many reports have focused on the synthesis of poly(styrene-acrylate) emulsions using semi-continuous emulsion polymerization methods [2–6], yielding copolymer emulsions with high-solid content and low viscosity [7, 8]. The semi-continuous process usually results in core–shell morphology, while batch emulsion polymerization often forms raspberry-like morphology or others [9, 10]. During semi-continuous emulsion polymerization, the integral composition of the copolymer, as well as the conversion process can be controlled by the feed composition and feeding rate, that is, copolymers with predetermined chemical composition distributions could be obtained [11, 12].

During emulsion polymerization, the use of emulsifiers is necessary to stabilize polymer emulsions and control particle sizes in order to produce continuous films.