Synthesis of Hybrid Epoxy resin Emulsion for Industrial Coating Applications

Introduction

The field of polymer chemistry since last few decades is approaching towards new eco-friendly route to develop polymers. This will minimize or eliminate the utilization of toxic chemicals, particularly organic solvents, which are hazardous to health and the environment (Kidwai M. 2005 & Chimankar Y. 2010). Scientists and technologists trying to innovate green technologies like powder coatings, UV cured coatings, solvent-less coatings, and waterborne coatings. Water-based coatings have become more widely used in the past several decades because they are environmentally friendly and eliminates organic solvents. Also their properties and application performance characteristics have been improved.

Epoxy resins have excellent characteristics, such as heat resistance, high strength, good corrosion resistance and good adhesion (Clayton A. 1988). Epoxy in combination with different hardener has been used as protective coatings (Ranjbar Z. 2009 & Patel H. S. 2011). However; they have some disadvantages like short pot life, poor or low fracture energy, high shrinkage, and brittle behavior (Xingshou P. 2004). The solvent based one phase epoxy system to be used in coating applications are reported in the literature (Patel D. P. 2011), but such systems contribute to volatile organic content (VOC) emission. The purpose of this work was to examine the feasibility of polymerizing acrylic monomers in the presence of epoxy resins to determine if this hybrid system could act as one pack system.

The term hybrid is basically defined as, the combination of more than two compounds to get the third one with properties different than participating compounds (Guyot A. 2007 & Patil R. N. 2010). Hybrid polymer can behave as homogeneous phase or can show phase separation within the particle. They are mainly classified as organic-inorganic and organic-organic hybrids based on the material used for modification of polymer. Simplest way to synthesized hybrid is blending of two participants from different families. However, there are some polymers which can’t be prepared by blending technique. In case of epoxy-acrylic polymer hybrid can be synthesized by radical emulsion polymerization.
Chapter 1

Synthesis of hybrid epoxy resin emulsion for corrosion resistance

Epoxy resin has been used for several decades for corrosion resistance applications in combination with a suitable curing agent. This two pack system has limited pot life after mixing. Epoxy coatings commonly are used because of excellent characteristics, such as heat resistance and good adhesion. The Acrylic latexes possess hydrolytic, light, and oxidative stability so that, we combine epoxy resin with acrylic latexes to achieve the advantage of the both systems. Thus, the hybrid of epoxy resin was synthesized with acrylate monomers which can act as one pack system stable for more than six months. The conventional emulsion polymerization technique has been used for hybrid synthesis. This technique is simple and economical compared to miniemulsion which includes preparation of per emulsion. We term emulsion polymerizations in which the polymerization of acrylate monomer is carried out in the presence of another resin for the purpose of forming graft copolymers and acrylate copolymer hybrid macroemulsion polymerizations.

Chapter 2

Study of various polymerization parameters of hybrid epoxy emulsion

The technique used to carry out the polymerization is simple emulsion polymerization in which epoxy resin is grafted with acrylate monomers using water soluble thermal initiator. The hybrid system synthesized had improved properties compared to acrylate or epoxy waterborne systems. The conditions of polymerization had an effect on the stability and performance of hybrid system. With each parameter of the system, properties of emulsion changes, making it necessary to study and fix the parameters of the system.

The main aim of this chapter is to highlight the effects that various factors on stability of hybrid epoxy-acrylate emulsions, in particular the overall conversion of monomers. The rate of polymerization was also determined from the plot of conversion versus time. Above mentioned factors include resin content, polymerization temperature, the percentage and type of initiator used for polymerization, and the amount of surfactant used for stabilizing emulsion.
Chapter 3

Application different curing agents for hybrid epoxy emulsion

Depending on the chemical structure of curing agents and on curing conditions, the properties of cured epoxy resins are versatile, including excellent chemical and heat resistance, high adhesive strength, low shrinkage, good impact resistance, high strength and hardness and high electrical insulation. Also the curing agent selection plays an important role in determining the properties of the finally cured epoxy. These properties include pot life, dry time, penetration and wetting ability etc. Curing agents come in many different chemical flavors, generally based upon amines or amides. Amine based curing agents are considered to be more durable and chemical resistant than amide based curing agents but most have a tendency to ‘blush’ in moist conditions. Also, most of the free amines are carcinogenic in nature. Amides, on the other hand, are more surface tolerant and less troubled by moisture.

The curing agents from different classes were used for curing reaction of hybrid epoxy resin. This includes primary amines, secondary amines, tertiary amines, polyamine and polyamide. Effect on shelf stability and corrosion resistance were evaluated. The curing agents from polyamide class shows excellent corrosion resistance compared to other agents, however the shelf life stability gets affected.

Chapter 4

Incorporation of nano silica particles

A hybrid of modified nano silica with polymer has been synthesized with microwave assisted emulsion polymerization technique. The nano silica powder was modified with two silane coupling agents, Vinyltrimethoxy silane (VTMS) and 3-glycidoxy-propyltrimethoxysilane (GPTS) having different functionality. Coupling reaction of silane agents with nano silica particles was performed in microwave reactor and confirmed by spectral analysis. The effect of nano silica particles on monomer conversion and stability of hybrid emulsions were investigated. Microwave reactor was found to be a useful tool for modification of nano silica particles with silane coupling agents. The result shows, with silane modified nano particle's final monomer conversion increases, attributed to increasing the affinity of nano particles towards acrylate
monomers. The SEM analysis of hybrid emulsion synthesized shows, uniformly spherical particles with narrow particle size distribution.

Chapter 5

Microwave assisted emulsion polymerization

Microwave assisted polymer synthesis is growing rapidly, due to their advantages over conventional heating methods. The microwave heating is a promising alternative for conventional heating due to its high heating rates and significant cost and energy savings. (Chandrashekaran S. 2001, Schubert U. S. 2007 & Wiesbrock F. 2004). With microwave assisted reaction immense increase in reaction speed and improved selectivity can be achieved. Microwave reactor has been introduced as a powerful tool for the synthesis of polymers. Consequently, more data will be very likely to be accumulated in the near future, probably focusing on more and more advanced techniques for hybrid synthesis (Jian-Shian L. 2011). The field of microwave heating is developing in order to fulfill the industrial applications (Shi S. 2003 & Leonellia C. 2010). This way, reaction times for future polymerizations can be decreased and the way to environmentally benign conditions will be paved.

Hybrid epoxy-acrylate emulsions were synthesized with increasing epoxy resin content with microwave assisted emulsion polymerization. The watt power of microwave radiations used for synthesis were found to have an effect on properties of emulsion. Microwave assisted emulsion polymerization technique is found to be very effective and fast method for polymer synthesis. Hybrid emulsions with the higher monomer conversion and molecular weight were synthesized.

Chapter 6

Comparative study of hybrid emulsion

The hybrid epoxy resin emulsion was synthesized with conventional emulsion polymerization technique. The properties of this hybrid must fulfill the industrial corrosion resistance requirements. The presence of impurities and by-products in epoxy resin formed during the
manufacturing process affects the final properties of hybrid emulsion. The hybrid epoxy emulsion was synthesized with epoxy resin of different epoxy equivalent and from different manufacturers. Also the properties of hybrid synthesized with epoxy resin from the same manufacturer but of different batches were compared. The two pack epoxy resin emulsion (DOW) properties were compared with one pack hybrid epoxy resin emulsion. The pot life of the hybrid epoxy resin emulsion was found to be superior compared to two pack epoxy emulsion.

Chapter 7

Electrochemical impedance spectroscopy study of hybrid epoxy resin coatings

Electrochemical Impedance Spectroscopy (EIS) has many advantages in comparison with other electrochemical techniques. It is a non-destructive method for the evaluation of a wide range of materials, including coatings, anodized films and corrosion inhibitors. It can also provide detailed information of the systems under examination; parameters such as corrosion rate, electrochemical mechanisms and detection of localized corrosion (Shylesha B. S. 2011). Polymer based coatings use barrier technology to protect substrates from corrosive chemicals and environments, particularly when in immersion service (Nadia H. 2011).

This chapter reports, the results of an investigation of the corrosion resistance of the hybrid coatings using EIS techniques. The hybrid one pack epoxy system was synthesized with conventional emulsion polymerization technique. The effects of coating thickness on water absorbance and ultimately on corrosion resistance were also studied. Nyquist and bode plots was analyzed to predict the corrosion performance of hybrid coatings. SEM analysis of the specimen was performed after immersion to get a closer view of coating degradation.
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