



Review

Crosslinked polymeric coatings: Preparation, characterization, and diffusion studies



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ABSTRACT

This work critically reviews the literature on diffusion and drying of crosslinked polymer – solvent coatings. Most of the literature reported so far belongs to various means of crosslinking, growth and control of crosslink densities, and effect of crosslinking on the properties of the coatings. Very few studies have been reported related to diffusion and drying of crosslinked polymeric coatings. In addition to critical analysis, the review outlines the limitations and proposes some future research guidelines in this area.

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Contents

1. Introduction	149
2. Preparation and characterization of crosslinked polymeric films	150
3. Diffusion in crosslinked films	157
4. Limitations and future scope of study	161
Acknowledgements	161
References	161

1. Introduction

Polymeric coatings are prepared by several methods with or without solvent. The polymers can be rubbery, crosslinked, or glassy in nature in the start of coating preparation. The crosslinked polymer films are used in various applications like protective coatings, paintings, barrier for separations of liquid and gases, storage media, semiconductors, micro fluidic devices, optical devices, fluorescent devices, surface acoustic wave devices drug release and encapsulation, and biomedical applications [1–11]. Multilayers and hybrid multilayers have attracted a lot of research due to their excellent properties like electrical, chemical, optical along with chemical and mechanical stability [12].

Crosslinking hardens the coatings and reduces the penetration of external molecules into the coatings [13,14]. Crosslinking also improves the surface coverage and enhances electrophoretic separations [15].

Crosslinking improves mechanical strength, chemical resistance, thermal stability, separation characteristics, biomedical properties, and other functional properties [16]. Crosslinking can be done by various ways like UV irradiation, chemical crosslinking, and hyperthermal hydrogen induced crosslinking. Hyperthermal hydrogen induced crosslinking is a unique technique because it does not require any co-agents or solvents and it is able to crosslink the material upto several microns. The depth of crosslinked material is very important to find the material properties.

During crosslinking, linear polymer chains join together at a common junction point [17]. The crosslinking agents are the low molecular weight compounds which chemically attach themselves to the ends of at least three chains. The properties of the polymer network are controlled by the degree of crosslinking. In case of a very high degree of crosslinking, the network will be very hard, brittle and solvent resistant [17]. Fluorescent devices require controlled deposition of crosslinked polymer based sensors [6]. The crosslinking degree can be manipulated to get the desired properties. This can be achieved by controlling curing temperature and crosslinking agent to monomer ratio.

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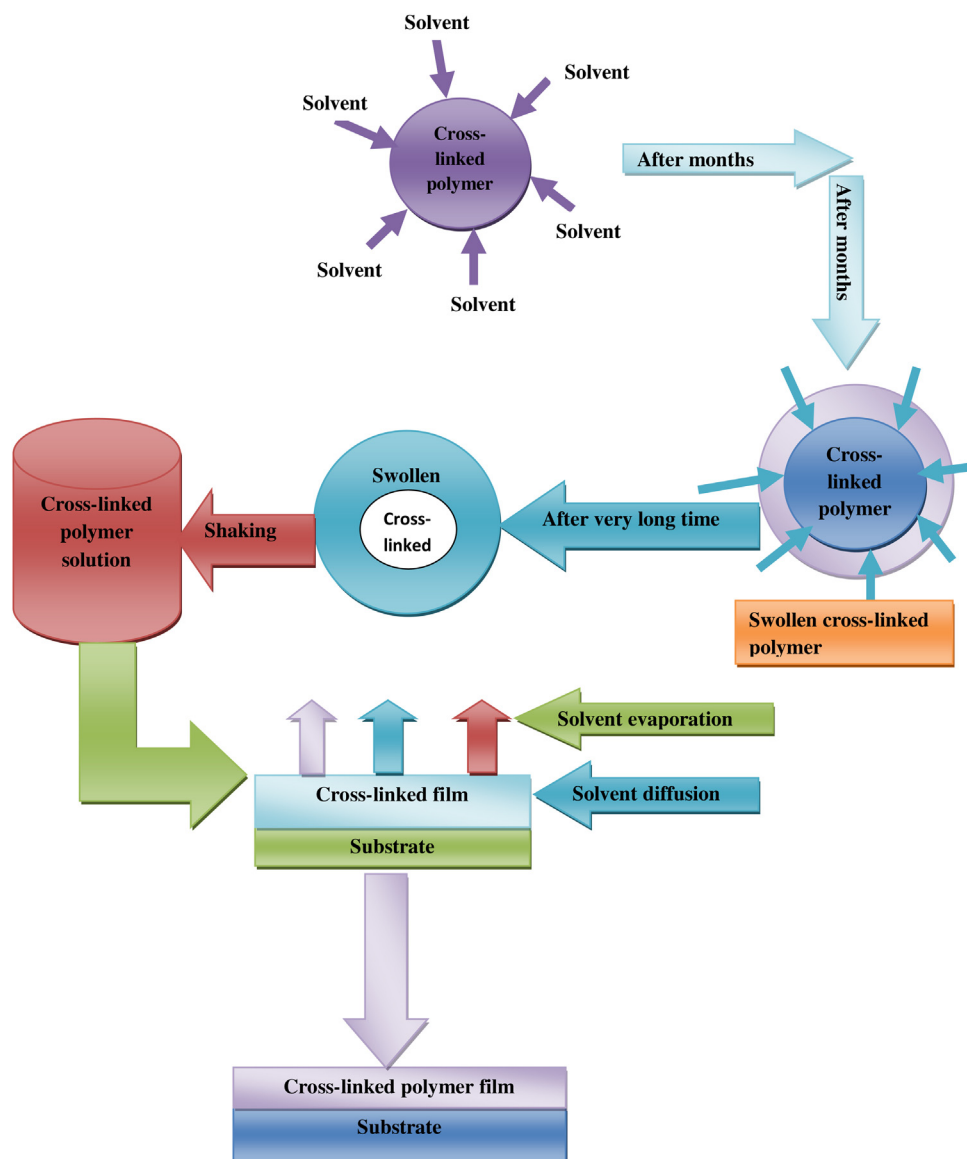


Fig. 1. Schematic of crosslinked solution coating preparation.

All coatings degrade when they get exposed to UV radiations due to the complex photochemical process. The weather conditions like moisture, temperature, and pollutants, etc. enhance this degradation process. The coating will degrade when it absorbs UV radiations and that is sufficient enough to break the bonds of polymer. The pure polymers do not degrade because they do not absorb sufficient energy of radiations greater than 295 nm wavelength, however the coatings will undergo degradation [2]. This shows that coatings have something other than the polymer. Improper drying and polymerization with other reacting species or ingredients are the main causes of degradation.

Durability of organic coatings can be enhanced by the addition of low molecular weight stabilizers [18]. These stabilizers absorb UV radiations which fall on the coating and, hence, stop the photooxidation of the coating since it does not allow UV radiations to react with the binder used in the coating. These UV absorbers also protect the subsequent layers of the polymer film. A few light stabilizer compounds scavenge the free radical produced during the oxidation process and, hence, slow down the oxidation process. UV absorbers and free radical scavengers are chemically destroyed during the weathering process [18]. Due to the weathering pro-

cess, the concentration of UV absorber at the surface decreases as compared to the deep inside the coating.

The transport of solvent in polymer(s) or polymer films is affected by unsaturation, degree of crystallinity, crosslinks density, and glass transition temperature [5]. The glass transition temperature increases with the solvent evaporation. For instance, an addition of 20% toluene in poly(styrene) makes the glass transition equal to the ambient temperature [3]. The diffusion coefficient decreases linearly with crosslink density and levels off at high values. The type of crosslinking governs the solvent uptake by the polymer. Fig. 1 shows the typical mechanism to cast the crosslinked polymer films using solution casting mechanism.

2. Preparation and characterization of crosslinked polymeric films

The lateral attachment of the polymer chains is called crosslinking or curing. The entire bulk of the polymer is converted into a three dimensional network structure. This makes the polymer harder and the mobility of the molecular chains decreases. Glass transition temperature and average molecular weight of

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