BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LVIII No. 2/2006	99 - 102	Seria Matematică - Informatică - Fizică

Pellicles and Films Making from Polymer Solution

Georgeta Nan

Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti 39, Ploieşti, Catedra de Fizică
e-mail: n_georgeta@yahoo.com

Abstract

In this paper there are presented some methods for making pellicles and films from a solution of polymer, films used for different experiments in polymer physics. The main methods used for this purpose are: a) spin-coating, b) self-inducing of making the structure, c) dip-coating d) the Ink-Jet deposition and e) the deposition on cylindrical surfaces.

Key words: *films, pellicles, polymer*

Introduction

The essential particularity of making pellicles from a solution of polymer consists in the obligation to ensure the conditions to obtain smooth surfaces still before the begining of the film concretion. On the one hand, a decisive role is played by the relation between the viscosity and the superficial tension of the system and by the concretion speed on the other hand.

The liquid pellicle is formed by casting on a rotative tambour, on a continous transporting band or direct in the bath of coagulation through a slit properly sized. At the casting on the band or on the tambour, the slit size depends mainly on the solution concentrations (to a set thickness); at the direct bath casting, the contraction is very important (40-50%) and must be taken into account.

The unification of the film surface is not made under the action of the gravitational forces but it is done mainly by the superficial tension which sometimes might be fully contrary to gravitation action. When the reinforcement of the film is made by evaporation, there are frequently used ternary systems which contains of two liquids each one a solvent with limited swelling possiblity. In this case, the drying process can be observed on a diagram of phases as shown in figure 1.

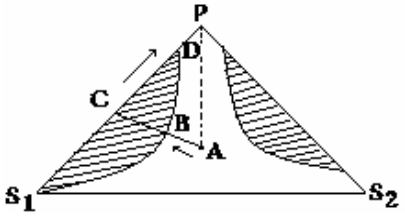

Fig. 1. The Scheme for obtaining the film polymer by the drying of a system with a polymer and two solvents

If from the solution of polymer discovered in point A on the diagram two solvents would equally evaporate during all the processes, the system would move on the line AP up to the complete drying (polymer 100%). Usually, the diffusion and the volatilization of the two liquids from the system are made with different speed.The evolution of the system could follow the line AB until the begining of the separation of phases, and then, following the segment BC up to the complete evaporation of the solvent S2 and the line CP up to the complete removal of the solvent S1.

Mainly, following the route ABCP, the pellicle will be heterogeneous; in many cases, the phases separation is visually observable by the appearance of the opalescencet film. In the drying process, in the film of polymer there appear internal tensions.

The source of such tensions is: in the case of systems with one solvent-the contraction limitation caused by the interaction with the support; in the case of systems with two non concentrated solvents –there appear supplementary sources of tension caused by the inhomogeneity of phase films (microzone). Practically, all technologies apply a controlled tension of the films with the intention to obtain a certain orientation of the polymer in order to finally confer the desired properties.

Methods of Making the Films

Spin-Coating (Cover the Sublayers with Films through Centrifugal Action)

In industry, spin-coating is considered to be the best method to uniformly deposit films with controllable thickness. It is the most representative technique. This method uses the centrifugal force produced by a disk in a very quick rotation in order to obtain a plastic film nearly perfect homogeneous with a thickness that varies between 100 and 200 nm.

A drop of solution of polymer is placed on the surface of the disk in rotation and it is scattered, creating a homogeneous film. The drip on the moving disk is observed by a synchronic moving device, which converts the rotative image in a static image captured by a video-cam.

The Four Stages of the Spin Coating

(a) The role of gravity force

Initially the surface is wet with a very concentrated polymer solution. Because relative big particles can produce flows on the surface, the fluid filtration is very important.

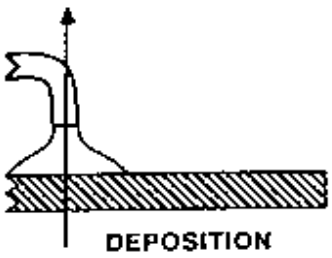

Fig. 2. Deposition

(b) The domination of the centrifugal force

The second stage of the Spin Coating is known as “spin –up”. The sublayer is accelerated up to its final speed and the fluid is scattered to the disk limits. The uniformity of the film doesn’t usually appear in this stage.

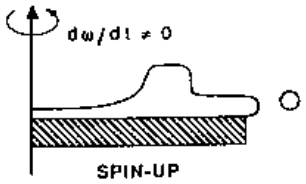

Fig. 3. Spin-up

(c) Domination of viscosity

During the third stage, the viscosity entirely dominates the system and the films are generally uniform. The film is getting thinner but at a smaller rate; and the excess fluid is still scattered.

To the sublayer brim the film isn't uniform because of the fluid drops gathered and deposited. Anyway, the film is uniform on the rest of the surface.

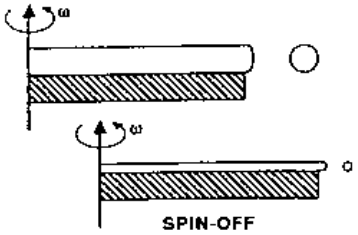

Fig. 4. Spin-off

(d) Domination of evaporation

In the end, the thickness of the film begins to stabilize while the evaporation of the solvent leads to quick growth of the fluid viscosity and becomes dominant ahead in the centrifugal forces. The outcome is an extremely thin and uniform film ready to be processed.

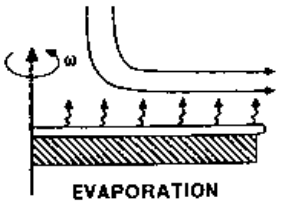

Fig. 5. Evaporation

The physics simulation of the spin-coat is based on the supposition that the fluid flowing is stable during the process.

An important model that develops from this supposition predicts the final thickness of the sublayer. The model also supposes that the early stages of the spin-coating are entirely dependent on the flowing, and the final ones are entirely dependent on the evaporation. The transition between these stages is known as the fluid-dynamic point of the coating process. It is discovered that the evaporation remains constant during the spin-coating as much as the rotation is constant.

Self-inducing as a Method to Make the Structure

One of the polymer deposition methods through spin-coating is self-inducing. This method allows the luminescent and semi-conductor polymers to make structural models on one specific sublayer. This process involves two heterogeneous polymers dissolved in one common solvent. The solution of these two polymers is applied on the sublayer through spin-coating. During the evaporation process of the solvent the two polymers separate.

The way in which the two polymers will be laid down, depends on the sublayer topography. If the sublayer is spongy, the polymers will be included in the system. One of the polymers is removed with the help of one selective solvent. The remained polymer will be the semi-conductor or the electro-luminescent one wished for the respective structure.

Dip-Coating

Dip-coating is a very simple process consisting of the deposition of the solution on a sublayer. In this case, the deposition is obtained through out the direct sinking of the sublayer in the polymer solution. The dip-coating is a much easier, faster and less expensive process compared to spin-coating. The layer laid down isn't very uniform and is too rough.

The Ink Jet Deposition

Ink-jet deposition is a method in which the polymer solution takes the place of the toner in the print device. In this method the polymer structure can be directly printed on a sublayer. With this method, the polymer solution can be applied on the sublayer with the precision of one pixel.

The Deposition on Cylindrical Surfaces

This method is relatively simple and consists in the deposition of the polymer solutions on a rotary support of cylindrical form. It confers a much attentive control of the thickness and uniformity of the film and especially through the centrifugal force created by the rotary sublayer; its distribution on the cylindrical cover makes it possible for the forming of a homogeneous film.

References

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Formarea peliculelor şi filmelor din soluţii de polimer

Rezumat

În această lucrare sunt prezentate câteva metode folosite pentru formarea peliculelor şi filmelor din soluţii de polimer, filme folosite în diferite experimente în fizica polimerilor. Principalele metode utilizate în acest scop sunt: a) spin-coating, b) auto-inducerea formării structurii, c) dip-coating d) depunerea Ink-Jet şi e) depunerea pe o suprafaţă cilindrică.