

RHEOLOGY OF THE CURING PROCESS OF ACRYLIC LATEXES USED AS CHEMICAL BINDERS

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ABSTRACT:

The structural development undergoing during the cure of a latex polymer is accompanied by viscoelastic changes, so that this process can be investigated using a rheological approach. We present in this paper the results of a study carried out on one of the most widely used chemical binders in the field of textile nonwovens: acrylic latexes. The rheological measurements have been performed on the latex films in a rectangular torsion and dynamic oscillatory mode, and the observations are discussed in terms of crosslinking. The results obtained show that the zone where crosslinking occurs in the polymer can be clearly identified by the investigation method used.

ZUSAMMENFASSUNG:

Strukturelle Veränderungen, die während des Aushärtens eines Latex-Polymer entstehen, sind durch viskoelastische Änderungen begleitet. Der Prozess kann daher durch rheologische Messungen untersucht werden. Wir präsentieren hier Ergebnisse einer Studie an einem der gebräuchlichsten chemischen Binder im Gebiet der Textil-Vliesstoffe: Acryl-Latex. Die rheologischen Messungen wurden an Latex-Filmen in Rechteck-Torsions- und dynamischem Oszillations-Modus durchgeführt. Beobachtungen werden im Hinblick auf den Vernetzungsgrad diskutiert. Die verwendeten Methoden geben einen eindeutigen Hinweis auf den Bereich, in dem Vernetzungen auftreten.

RÉSUMÉ:

Pendant la cuisson d'un latex, il y a formation d'un réseau macromoléculaire qui s'accompagne d'une variation des propriétés viscoélastiques: ce processus peut donc être suivi par une approche rhéologique. Nous présentons dans cette publication les résultats d'une étude réalisée sur l'un des liants chimiques les plus courants dans le domaine des nontissés textiles: les latex acryliques. Les mesures rhéologiques ont été effectuées sur des films de latex en torsion rectangulaire et en mode dynamique. Les résultats observés sont discutés en termes de réticulation et montrent que la zone précise de réticulation du polymère peut être clairement identifiée par cette méthode.

KEY WORDS: acrylic latex, cross linking, curing

1 INTRODUCTION

Nonwovens [1] are sheet-like fabric structures made up of fibre webs which have been bonded either chemically, mechanically or thermally to achieve a cohesive fabric. In chemical bonding, the fibres are interlocked by the application of a chemical binder, and the strength of the adhesion between the fibre and the binder is of great importance, for evident mechanical and durability reasons. Indeed, much research work is devoted to the improvement of this adhesion through different techniques, for instance by modifying the fibre surface by plasma treatment [2]. The

study of this fibre/binder adhesion represents therefore an important issue to technologists involved with chemically-bonded nonwovens, and in this paper, we propose a basic approach to this problem through the study of the binder. We employ a rheological technique to understand more particularly the curing - and crosslinking - process of the binder which is a complex polymeric fluid. Other approaches found in literature include studies of crosslinking of polymers by differential scanning calorimetry [3, 4] or thermogravimetry [5].

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the dried sample heated at 70°C have both already lost practically all their water content during their respective thermal treatments. The peak obtained for the 3 samples above 180°C is a result of degradation and can be compared to the fall in G' observed at these temperatures.

These results show that the crosslinking reaction leads to the formation of by-products which do not remain in the film. The crosslinking mechanism for the acrylic latex studied is now recalled in order to explain the results obtained. The latex is an acrylic polymer copolymerized with NMA, N-Methylol Acrylamide ($\text{CH}_2 = \text{CH}-\text{CO}-\text{NH}-\text{CH}_2\text{OH}$). N-Methylol groups are heat reactive groups which will allow crosslinking to take place during drying at high temperature according to the following mechanism: on the application of heat ($T = 100 - 160^\circ\text{C}$, crosslinking temperature range), the terminal OH of the NMA groups will react together, linking the polymer chains with ether bonds, while water is released. Other reactions may also take place, with the formation of methylene bonds instead of the ether bonds. The by-products of this condensation reaction – essentially water, and sometimes formaldehyde – evaporate from the latex during the curing process: this explains the weight loss observed around 140°C.

5 CONCLUSIONS

The rheological technique employed in this work has proved to be well adapted to investigate the curing and crosslinking processes of acrylic latexes. In conclusion, we can make the following important observations:

- a transition of the storage modulus is observed when crosslinking takes place, even if its amplitude is not very high compared to other polymeric systems
- the exact temperature range in which this transition occurs can be determined by rheological measurement
- a rapid onset of thermal degradation, at around 180°C, occurs in these latexes.

The difference in rheological behaviour between a crosslinked film and a dried film which is only coalesced has been clearly highlighted. The results obtained are in conformity with the behaviour of the latex in thermogravimetric

analysis. This study contributes to a better understanding of the curing mechanism of acrylic binder systems, which in turn will help achieve improved characteristics in the nonwoven products where they are used. The rheological study is complementary to other existing techniques like DSC or thermogravimetry, but it is the only one which provides important information on the final mechanical properties of the polymer. Suitable conditions for processing these latexes have been determined with this method, and this will be particularly valuable in the study of the latex/fibre adhesion in the nonwovens. Zosel [21], working with acrylic latexes and polydimethylsiloxane, showed that crosslink density has a great influence on the adherence and mechanical properties of polymers, and we shall now investigate this aspect with our latexes.

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