

Stability analysis of tannin-based foam using multiple light scattering measurements

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Keywords: Tannin, foams, characterization, instability, foam capacity, multiple light scattering

1 Introduction

A new simple way for producing highly porous tannin-based foams, not based on physical or chemical foaming, was recently presented by Szczurek et al. [1]. Such formaldehyde-free rigid foams made by polymerization of a liquid foam obtained by strong whipping of aqueous tannin solutions containing surfactant and crosslinker, were reported and characterized in the aforementioned paper. As a result, new rigid foams with completely comparable features to those of former similar materials but obtained by conventional techniques were presented. These materials are very promising especially in thermal insulation and fire resistance applications. A better and systematic understanding of the instabilities of liquid tannin foam as well as the process of polymerization by which the liquid foams harden before they can collapse or destabilize is necessary in order to optimise the material and to control its behaviour.

The objective of the present work was to provide information on the liquid foam decay process by establishing relationships between the behavior of the foam and basic parameters such as amount of surfactant, stirring time or temperature. Especially, the temperature is a crucial parameter to be investigated because, in addition to its major effect on the liquid foam stability, it triggers the crosslinking process that ends with rigid foam.

The stability of the foam was determined using a recently developed optical analyzer (TURBISCAN LAB from Formulation, France). It is based on a light-scattering detection method which has been successfully used to study the stability of emulsions, foams and concentrated dispersions [2]–[4]. It allows detecting any destabilization phenomenon that may happen in the foam at the same time, e.g. particle migration (creaming, sedimentation) and/or particle size variations (coalescence, flocculation). The main advantage of the Turbiscan Lab analyzer is its ability to detect these phenomena much earlier and more precisely than the naked eye's operator, especially in the case of opaque and concentrated systems such as tannin-based foams. Moreover, it is a nondestructive method, and no sample dilution is needed.

2 Methods

Immediately after the preparation of the liquid tannin foams by mechanical beating at room temperature, their foaming capacity or volume fraction of air were determined. Afterwards, the foam destabilization was analysed during 24h by recording the transmitted (I) and/or backscattered (BS) light as a function of foam height and time. For that purpose, a laser repeatedly scanned up and down the samples, and the increases or decreases in the intensity of signals taking $t = 0$ s as reference were represented graphically. In the present case, only backscattering data were analysed by Turbiscan's software because tannin foams are practically opaque all over the experiments.

3 Results and discussion

The analysis of the backscattering profile of liquid tannin-based foams gives information about the different phenomena of destabilization that may occur as a function of time. The main instabilities that were found in liquid tannin foams at room temperature are shown in Fig. 1.

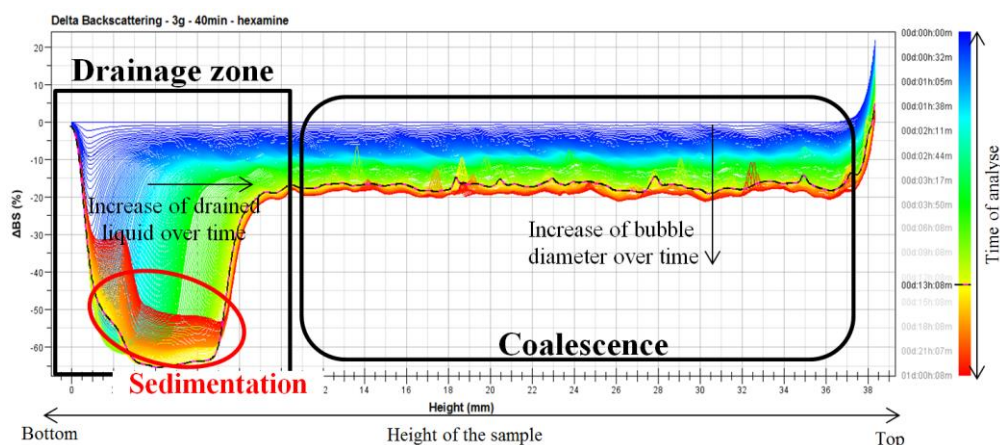


Figure 1: Typical backscattering profiles of tannin-based foams evaluated by Turbiscan.

The drainage of fluid was identified by a negative peak of BS at the bottom of the sample holder that became deeper and wider with time because of the opaque drained tannin solution. A second phenomenon was detected in the middle of the glass tube: the increase of bubble diameter by coalescence observed as a progressive decrease in the backscattering profile [5]. Finally, there was a third phenomenon defined as sedimentation that has been proved to be due to the presence of crosslinker in the specimen. BS signal begins to increase in the bottom once the drainage is less significant.

Once the different kinds of instabilities were identified, the way they are affected by each parameter under study was analysed. The effect of surfactant and stirring time on the liquid foam stability was investigated at room temperature, using tools such as drainage rate, amount of sedimentation, index of destabilization or change of bubble size, among others, for establishing trends. On the other hand, the assays at different temperatures were carried out to study the changes of foam volume.

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