Study of the Continuous Gelation Process of Non-aqueous Carbopol Gels

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Manufacturing processes involving complex non-Newtonian fluids are employed in several industrial applications. Specifically, the design of new continuous mixing operations poses many challenges, especially when highly viscous non-Newtonian fluids are treated. Typically, batch processes are employed to perform blending in high viscosity conditions. However, the large fluid volumes that characterize these operations can lead to concentration and temperature gradients within the vessels and to the establishment of dead mixing zones for more viscous fluids. New continuous processes can prevent these problems and achieve better performance at lower costs[1]. It may also be possible to separate processing steps leading to modular approaches. Despite the several advantages that could arise from the use of a continuous approach, shifting from a batch to an in-line process is not usually straightforward. In many industrial applications, during the mixing process, fluids undergo rapid changes in rheology due to polymerization, heat transfer or simple homogenization of different phases. For process design purposes, numerical methods, such as computational fluid dynamics, represent a valuable tool to achieve a quicker and more cost efficient investigation of all the different process variables. However, when dealing with complex fluids, knowledge of the rheological behaviour is important for obtaining meaningful results.

In this work we investigate a method to develop a new continuous gelation process with specific focus on the numerical implementation of the time-evolution of the rheological properties. The process of interest is the gelation of non-aqueous Carbopol® dispersions, currently used in novel formulations of oral health products. We used Fourier Transform Mechanical Spectroscopy (FTMS) [2] to track the evolution of the rheological properties of the mixtures and obtain operating maps (examples in Figure 1) in terms of a structural conversion degree X_s, at different solvent compositions and operating temperatures; these can be further linked to the evolution of the viscosity of the mixtures. The generalized kinetic model was then used in a computational fluid dynamics study of the gelating flow in a small channel. Lastly, to validate the numerical results, we compared pressure drop and velocity profiles with values measured experimentally from gelation experiments in flow at different residence times.

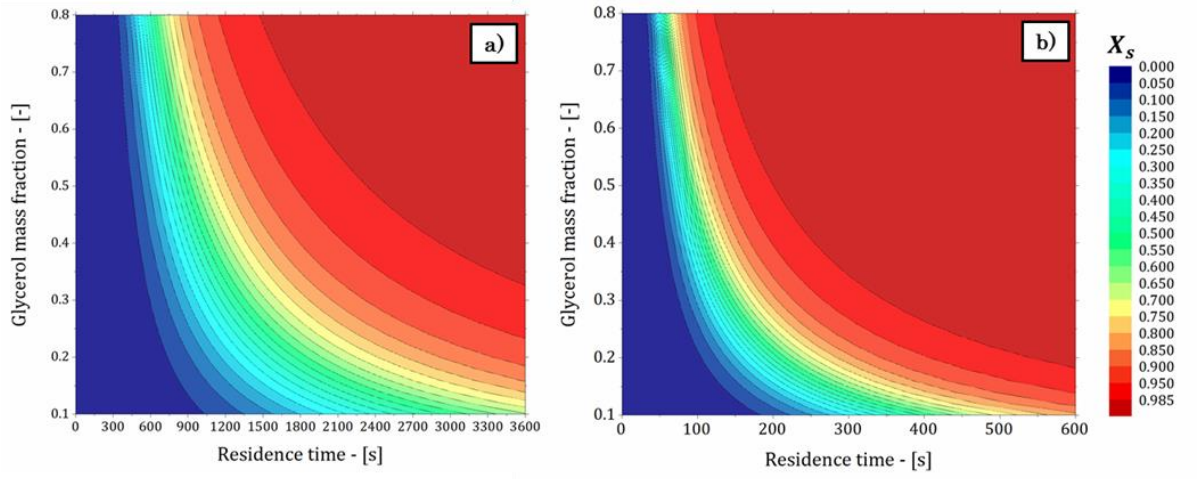

Figure 1: Operating maps reporting the structural conversion degree X_s against residence time and glycerol mass fraction at a temperature of a) 25 ºC, b) 40 ºC.

References

[1] H.E.H. Meijer, M.K. Singh, P.D. Anderson, *Prog. Polym. Sci*. 37 **2012**, p1333.
[2] E.E. Holly, S.K. Venkataraman, H.H. Winter, F. Chambon, *J. Nonnewton. Fluid Mech*. 27 **1988**, p17.