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The effect of chemical composition on viscoelastic properties of methylcellulose/agarose hydrogel

B. Niemczyk*, P. Sajkiewicz

Institute of Fundamental Technological Research, Polish Academy of Sciences
Pawińskiego 5b, 02-106 Warsaw, Poland

** bniem@ippt.pan.pl*

Appropriate kinetics of hydrogels cross-linking is very important, particularly for thermosensitive materials directed toward tissue engineering applications. In this regard methylcellulose is widely used, however there is only a handful of publications describing the characteristics of the methylcellulose/agarose composite. The aim of the studies is to analyse the kinetics of cross-linking of aqueous solutions of methylcellulose and methylcellulose/agarose using dynamic mechanical analysis (DMA).

The oscillatory analysis was performed for few concentrations of pure methylcellulose and methylcellulose/agarose utilizing small-amplitude sinusoidal deformation. In the temperature range 33-39°C, under isothermal conditions time dependence of storage G', viscous modulus G'' and complex viscosity were determined in limited range of time. Considering that there is no intersection of G' and G'' curves, the kinetics of cross-linking was deduced from the time derivative of the storage modulus G'. As a parameters of cross-linking, the time position and the height of the maximum of the time derivative of the storage modulus were taken. The numerical analysis including approximation and extrapolation beyond the registered time with asymmetric double sigmoidal function as well as integration allows estimation of the final modulus and complex viscosity of hydrogels which is crucial from the practical perspective.

Our results show that addition of agarose to methylcellulose hydrogel at the w/w ratio 1:2 and 1:3 does not affect very much viscosity what is important for injectability. However at physiological temperature the presence of agarose influences the cross-linking kinetics leading to higher rate of cross-linking (higher maximum of the storage modulus derivative) and the final value of the storage modulus. For instance, at 35°C agarose addition leads to an increase of the final G' and complex viscosity 1100- and 13-times respectively compared to pure methylcellulose. Moreover, addition of agarose results in increase of the time position of the maximum of crosslinking rate.

Keywords: methylcellulose, agarose, hydrogel, cross-linking kinetics, DMA, modulus