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Viscosimetric study of aqueous solutions of glucosamine and its mixtures with glucose

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Abstract

At present, glucosamine is an important substance for its future use in food products to contribute therapeutical characteristics to the product. In the present paper, the viscosimetric behaviour of aqueous solutions of this solute has been carried out. For a deep characterization, the effect of composition and temperature have been analysed. Also the effect of addition of glucose upon the viscosity of the solution has been studied. The viscosimetric behaviour of aqueous solutions of glucosamine and the mixtures with glucose has been modelized with equations for one and two solutes obtaining suitable results.

Keywords: Glucosamine; Viscosity; Density

1. Introduction

In recent years, glucosamine and other products such as chondroitin have been widely promoted as a treatment for arthritis and placebo-controlled studies. Glucosamine has been shown to rehabilitate cartilage and reduce the progression of osteoarthritis, and significantly lessen pain from arthritis. Glucosamine is an amino sugar that is present in all human tissues and is thought to promote the formation and repair of cartilage. This substance is the principal compound of the glucosaminoglycans (GAGs) that form the matrix of the connective tissues.

In some cases the glucosamine could be combined to others GAGs since this compound keeps the viscosity in the articulation and stimulates the cartilage recovery. The low molecular weight of the glucosamine means that it substance will be absorbed easily and in a high grade into the intestine. Also, an anti-inflammatory effect has been observed in relation to the cartilage metabolism.

The use of this additive in animal and human food has become quite common and for this reason, the flow characteristics are interesting. The combined use of glucosamine with other solutes is an option to enrich food and has been examined in dairy products (Flood & Puagsa, 2000). In recent years, several authors have studied the effect of numerous solutes upon the physico-chemical properties with more interest in density and viscosity (Cibulkova, Vasiljev, Danek, & Simko, 2003; Moreiras et al., 2003; Palaiologou, Molinou, & Tsierkezos, 2002; Vázquez, Varela, Cancela, Álvarez, & Navaza, 1996). Solutes such as sucrose, glucose, glycerine, carbonates, phosphates, sulphates, etc., have been analysed on the basis of their physical properties in literature. The trends observed by these researchers have not been clear and different behaviours have been analysed. In most of cases, the effect of the solute presence produces an increase in the value of the property analysed when the solute concentration increases but Pereira,

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Moreira, Vázquez, and Chenlo (2001), found that the presence of certain solutes decreased the kinematic viscosity.

Several authors have developed different equations that correlate the experimental values of density and viscosity for aqueous solutions of one solute. In the case of density, different formulations have been published. Vázquez, Álvarez, Varela, Cancela, and Navaza (1996), used an equation based on the value of the solvent (water) density and a polynomial contribution of the solute concentration. When this equation was applied to ternary mixtures (water + solute 1 + solute 2), the solvent density is the corresponding density of water + solute 1. On the other hand, other authors (Bettin, Emmerich, Spieweck, & Toth, 1998; Pereira et al., 2001), have contributed equations relating relative density to solvent density. The equation proposed by Pereira et al. (2001) included the effects of composition and temperature while the Bettin et al. (1998) equation only correlated density values with the composition. Also, the equation developed by Pereira et al. (2001) is a predictive model, based in characteristics parameters for each solute. Also, in recent years, studies based on neural networks to correlate data of multicomponent mixtures have produced some papers (Comesaña, Otero, García, & Correa, 2003).

With regards to viscosity, Vázquez, Álvarez, and Navaza (1998), contributed a similar equation to that previously mentioned by some of these authors for density. Kumar (1993), developed a complete equation for prediction absolute viscosity for binary mixtures (one solute). Pereira et al. (2001), completed these studies and modified the equation proposed by Kumar (1993) to obtain a predictive equation for kinematic viscosity based on characteristics parameters of the solutes employed.

The present paper tries report density, kinematic viscosity and absolute viscosity behaviours for aqueous solutions containing glucosamine and the influence of the presence of glucose upon the trends observed.

2. Materials and methods

The solutes employed in the present paper, D (+) glucose and D (+) glucosamine hydrochloride (2-amino-2-deoxy-D-glucose hydrochloride) (Fig. 1), were supplied by Fluka with a purity ⩾99%. Aqueous solutions of glucosamine and glucose + glucosamine were prepared by mass using an analytical balance with a precision of $\pm 10^{-7}$ kg. In all cases, the prepared solutions were filtered using Millipore filters with a pore diameter of 0.22 μm. For these solutions, doubly distilled water was employed.

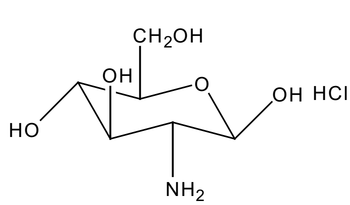

Fig. 1. Glucosamine structure.

In the present paper, different concentrations of glucosamine in the aqueous solutions, in the range of solubility of this solute in water (0–0.4 mol dm^{-3}) were studied for this system in relation to density and viscosity. Also, the same concentration range was employed for glucose in the ternary solutions.

Density measurements of the corresponding mixtures were carried out using pycnometers (Gay-Lussac's pycnometer with a bulb volume of 25 cm^3). The pycnometers were placed into a thermostatic bath maintained a constant temperature with ±0.1 °C.

The kinematic viscosity (ν) was determined from the transit time of the liquid meniscus through a capillary viscosimeter supplied by Schott (Cap No. 0 c, 0.46 ± 0.01 mm of internal diameter, $K = 0.003201$ mm^{2}s^{-1}) using Eq. (1). The viscometer used was a Shott-Geräte AVS 350 Ubbelohde type

$$\nu = K(t - \theta) \tag{1}$$

where t is the transit time, K is the characteristic constant of the capillary viscosimeter, and θ, is a correction value to prevent the final effects. An electronic stopwatch accurate to within ±0.01 s was used for measuring times.

The glass capillary was immersed in a bath controlled to ±0.1 °C to determine the viscosity in the range temperature between 25 and 50 °C and then study the effect of the temperature on the viscosity. Each measurement was repeated at least six times. The dynamic viscosity (η) could be obtained by the product of kinematic viscosity (ν) and the corresponding density (ρ) of the binary mixture in terms of Eq. (2) for each temperature and mixture composition.

$$\eta = \rho \cdot \nu \tag{2}$$

Density and viscosity values for bi-distillate water and binary mixtures of water + glucose were determined and used to confirm that the methods employed in the present paper (picnometric and capillary methods) contributed suitable results for comparison with the literature values (Vázquez et al., 1998).

3. Results and discussion

3.1. Water + glucosamine system

Figs. 2 and 3 show the results obtained for the value of these physical properties in the concentration range indicated in the materials and methods section. The