Data Descriptor

Determination of Changes in Viscosity of Hydrogel Depending on Shear Rates

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Abstract

The datasets entitled Determination of changes in viscosity of hydrogel depending on shear rate contain the results of viscosity measurements using a Brookfield viscometer, with different kinds of spindles and shear rates. The data allowed the used hydrogel preparations to be characterised and their functional parameters, as substances modifying the rheology of thickeners and determining the effect of shear rate on the viscosity of hydrogels, to be assessed.

Keywords: viscosity, hydrogel, shear rate, Brookfield viscometer

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Specification table (data records)

Subject area	Materials engineering, Biomedical engineering
More specific subject area	Measurements of rheological properties of hydrogel
Type of data	Text
How the data was acquired	The data were collected at the Gdańsk University of Technology using a Brookfield viscosity test machine with the Rheocalc V2.7 software
Data format	The tables are in .xls and .csv formats
Experimental factors	The data contained in the datasets were not processed

Experimental features	The dynamic viscosity data were collected under different kinds of spindles and shear rates
Data source location	MOST Wiedzy Open Research Catalog, Gdańsk University of Technology, Gdańsk, Poland
Data accessibility	The datasets are accessible and are publicly and freely available for any research or educational purposes

Background

Rheology is an appropriate method for characterising hydrogel mechanical properties since it is quick, sensitive, requires small sample sizes, and is revealing of differences in architecture such as degree of crosslinking, proximity of the glass transition, structural homogeneity/heterogeneity, and molecular weight. There are a number of reviews of the rheological properties of hydrogels composed of proteins, polysaccharides, or both (Tylingo, Mania and Szwacki, 2016). Compared to other synthetic biomaterials, hydrogels have physical properties similar to living tissue due to their relatively high water content, softness and plasticity. The polymer chains that make up the hydrogel network can be linked by chemical bonds, or their structure can be maintained by molecular bonds, additional ionic forces, hydrogen bonds or hydrophobic interactions. In the first case, hydrogels, depending on the size of the polymer-water interaction and the density of connections between the polymer chains, reach an equilibrium swelling state and are called solid or chemical gels. In the second described case, the hydrogels are called reversible or physical gels, respectively. Physical and chemical hydrogels can adopt a wide variety of macromolecular structures consisting of cross-linked or entangled linear homopolymers, linear copolymers, or block and graft copolymers. The network can be stabilised by the reaction of a polyion and polyvalent ions, or two polyions, resulting in complexes containing hydrogen bonds and others (Swarbcick and Boylan, 2000). Hence, the use of viscosity measurements to assess the quality of created hydrogels is a good analytical tool.

Our dataset series entitled "Determination of changes in viscosity of hydrogel depending on shear rate", has been created to enable the determination of the rheological properties of hydrogels composed of natural polymer solutions. The datasets contain: dynamic viscosity, speed and torque of the spindle, shear stress and the information of the temperature and spindle type used for measurement. These data allow the determination of the flow curve of the tested fluid.

Methods

Most rotational viscometers / rheometers work according to the Searle principle: A motor drives a spindle inside a fixed cup. The rotational speed of the spindle is preset and produces the motor torque that is needed to rotate the measuring bob. This torque has to overcome the viscous forces of the tested substance and is therefore a measure for its viscosity. A rotational viscometer measures the dynamic viscosity [η] of a sample.

Newton's Law defines the dynamic viscosity η as the shear stress divided by the shear rate (Mezger, 2011). When we measure the viscosity on a rotational viscometer, we apply to the sample a certain shear stress or a certain shear rate, respectively. The physical properties speed and torque can be translated into the rheological properties shear rate and shear stress if the measurement is performed using a standard measuring geometry according to ISO 3219. The viscometer's speed is converted into shear rate using a conversion factor (the factor depends on the measuring geometry used) and the torque is also converted into shear stress using a conversion factor. Usually, this is automatically done by the instrument.

$$\text{speed} \times \text{conversion factor} = \text{shear rate}$$
$$\text{torque} \times \text{conversion factor} = \text{shear stress}$$

In a typical rotational test, the shear rate is preset. This means that the viscometer translates the chosen shear rate into speed and measures the resulting torque, which it then translates into shear stress. Such a measurement, where the shear rate is increased and the resulting shear stress is measured, is called a flow curve.

During the test, the effect of adding a thickener in a wide range of concentrations on the change of the viscosity of a hydrogel prepared on the basis of a natural polymer was checked. All samples were prepared for measurement as follows. Before starting the measurement, the liquid sample was thermostated for at least 5 hours in a laboratory chamber at the measurement temperature.

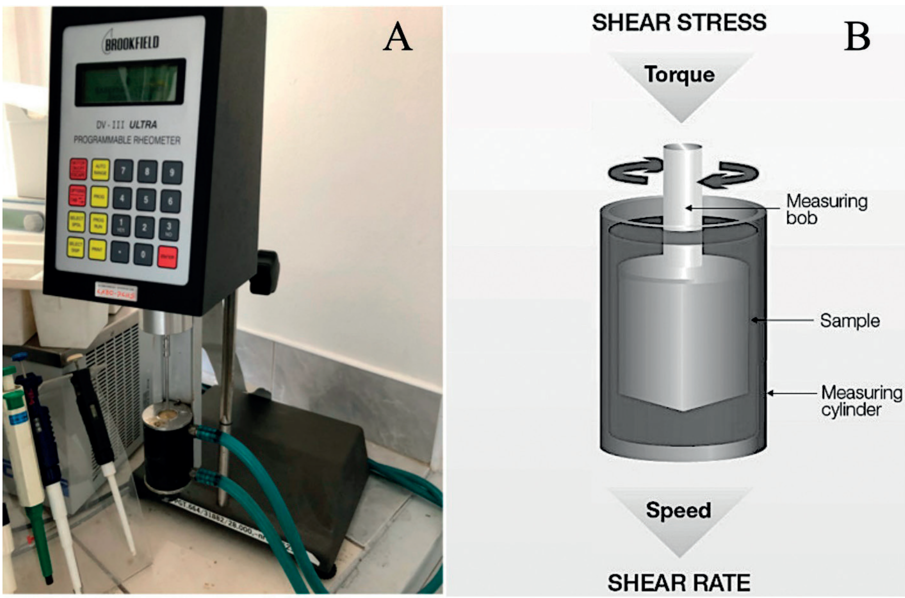

Fig. 13.1. Presentation of the main measuring device of the Brookfield DV-III+ viscometer: (A) main measurement unit, (B) principle of operation

Based on a preliminary visual viscosity assessment, the appropriate sample volume was transferred to the measuring cell and mounted in the thermostatic jacket of the apparatus. Next, after resetting the viscometer indications, the appropriate spindle (LV SC4 – 27 spindle and shear rates from 1.7 to 34 s-1, LV SC4 – 25 spindle and shear rates from 1.1 to 55 s-1, LV SC4 – 18 spindle and shear rates from 6.6 to 330 s^{-1}) was installed and the measurement was started. Measurements were performed in time intervals with a stabilisation time of the viscometer indications of 10 minutes for each shear rate.

Data quality and availability

All measurements were collected using a Brookfield DV-III+ viscometer (Labo Plus), using the Rheocalc V2.7 software and typical operating parameters, described within each experimental file. The datasets may be opened with any calculation processing software capable of recognising text or XLS files.

The flow curves were measured in triplicate. Before starting each measurement, the instrument readings were zeroed so as not to generate spindle stress before starting the measurement (measurement error below 3%). Additionally, before each series of measurements for the same tests, the viscometer was calibrated on the basis of selected certified viscosity standards in the form of silicone oil in the range of 100–100,000 mPas at 25°C.

Datasets DOI
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10.34808/63qr-f068
10.34808/vmm8-4d37

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References

Mezger, T. (2011) 'The Rheology'. Handbook. *European Coatings Tech Files*, 3rd ed., Hanover: Vincentz Network.

Tylingo, R., Mania, S. and Szwacki, J. (2016) 'A novel method for drop in drop edible oil encapsulation with chitosan using a coaxial technique', *Reactive and Functional Polymers*, 100, pp. 64–72. DOI: 10.1016/j.reactfunctpolym.2016.01.001.

Swarbcick, J. (2000) '*Encyclopedia of Pharmaceutical Technology*', Informa Healthcare, USA, New York, Available at: https://gmpua.com/Process/EncyclopediaPT.pdf (Accessed: 25th May 2022).