Dynamic viscosity

THEORY

All liquids are imperfect fluids. This is caused by inner friction that all particles have to overcome during mutual movement. Friction depends on temperature, chemical composition and concentration of liquid or solution. Generally dynamic viscosity η expresses resistance against the mutual movement of two layers of liquid. Its unit is $N \cdot m^{-2} \cdot s = Pa \cdot s$.
Moreover, viscosity of some liquids is in nonlinear relation to shear stress and velocity gradient (in this experiment supplied by changing weight) in liquid. In case of these liquids (called **non-newtonian**) absolute value of viscosity can be determined only for exact conditions.

- **DYNAMIC VISCOSITY**

To measure very viscous liquids, one can use **push-ball rheoviscometer**. It allows viscosity measurement up to the values of $4 \cdot 10^{3}\,\mathrm{Pa \cdot s}$. Measured liquid is placed into calibrated tube and exactly dimensioned ball is pushed through thanks to a weight added onto viscometer arm. Path length travelled by ball is measured by exact indicator and time needed is measured also. If we employ same path length for all measurements, value of viscosity can be expressed as:

$$\eta = k \cdot m \cdot t$$

Where *k* is constant defined by manufacturer of viscometer or experimentally found by measurement of liquid with known viscosity using specified ball and tube, *m* is mass of used weight and *t* is time of the ball movement.

TASK

- Find the *k* value of push-ball viscometer using glycerol solution of known viscosity.
- Measure the viscosity of 1% carboxymethylcellulose and 1% hydroxyethylcellulose.

EQUIPMENT AND CHEMICALS

- Push-ball viscometer; 85 % glycerol, 1% solutions of CMC and HEC, set of weights, pincers.

PROCEDURE

- Find *k* value using 85% glycerol of defined viscosity (80.167 mPa · s).

- Pour glycerol into tube (*01*, *94866*) up to about 2 cm under the edge. Put ball on stick into the tube and place it in sample holder (1). Fix the free end of stick into locking mechanism (2). Place weight of known mass (**use analytical scales and pincers to measure the mass**) onto weight tray (3). Turn the lock knob (4) clockwise to set the arm free and measure time in which the ball passes between 0 and 30 mm on path length indicator (5). After the measurement, turn lock knob counter clockwise to move the ball into start position.
- Repeat the measurement **3 times for one weight** (**use the same glycerol solution, no need to discard it between measurements**). Use 3 different weights, so that the measured time always exceeds 15 s (3×3 measurements – 9 time values total). Use weights in total mass: **20, 40 and 100 g**. Express *k* value for every weight used. In ongoing experiment use the **average of three values** obtained.

- Determine the viscosity of 1% solutions of CMC and HEC. Use 3 different weights for every sample and obtain 3 time values for each of them (3×3 measurements for each sample – 18 time values in total). Use weights in total mass: **10, 20 and 40 g** for CMC and **40, 80 and 120 g** for HEC.
- Thoroughly clean the tube and the ball at the end of measurement using purified water.

PROTOCOL

- Push-ball viscometer: create a table with obtained times, used weights, computed *k* values and the average *k* value used in ongoing experiment.
- Also create a table of obtained times, used weights and computed viscosity values for samples.
- Create a graph expressing dependence of viscosity on the mass of weight used for every sample.
- Comment the behaviour of solutions. How does viscosity changes in relation to used weight? Find a name for this specific type of non-newtonian fluid (for example – shear thinning, thixotropic or other).