Polymeric Materials

Faculty of Chemistry, Stationary Mode 2nd grade

year 1, semester 2

Manual developed by:

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Exercise – 1 Water regain and swelling properties of polymers

Polymers are macromolecular compounds built of macromolecules characterized by different properties from low molecular weight compounds. They have a high molecular weight, above 10,000. Compounds with a mass greater than 10,000 have a set of characteristic properties different from the properties of small molecule compounds (eg mechanical strength, flexibility, plasticity and specific behaviour in solution). As the largest molecular mass of low molecular weight compounds, the value of 500 is conventionally assumed, whereas in the mass range 500 to 10,000 there are compounds called oligomers, similar in structure to the polymer macromolecule but different properties from the monomer and the final polymer.

Macromolecules (i.e. long-chain molecules) of polymers consist of repeating atomic groups, i.e. mers. The materials for obtaining polymers are low molecular weight compounds, called monomers, which must be at least bifunctional.

Polymers, unlike low molecular weight compounds, may be spatially crosslinked structures. Due to the specific structure, polymers behave differently in solvents (organic and water). Cross-linked polymers will never dissolve, because their chains are covalently bound by covalent bonds.

The dissolution process of non-crosslinked polymers is a long-term process preceded by a swelling process. In this step, solvent molecules whose mobility many times exceeds the mobility of polymer macromolecules slowly penetrate (diffuse) into the polymer macromolecule. Then, the solvent causes the polymer macromolecules to be further distanced (dispersed) and finally separated from each other. Then a homogeneous real polymer is formed.

In contrast, cross-linked polymers are only swollen in a suitably selected solvent.

The aim of the exercise is to assess the ability of crosslinked polymers to swell and to determine the water absorption of polymers in an aqueous environment.

1.1. Swelling of polymers

This task will use Terra Hydrogel Aqua hydrogel polymers based on crosslinked sodium or potassium polyacrylate with different granulation: **dusty** 60-80 mesh and **granular** 10 - 40 mesh (given in Table 1).

The Mesh scale is commonly used to determine the grain size of bulk and granular materials. The number of the grain in this scale means the number of sieves on the length of one inch, i.e. 2, 54 cm, through which the material was poured and stopped on another sieve with smaller mesh. Screen number, i.e. the number of "mesh" means the number of eyelets per 1 inch (25.4 mm) screen length. Appendix 1 gives examples of grain sizes on a mesh scale.

Terra Hydrogel Aqua occurs in two different states:

1. **Hydrogel in granular form** it is used for specialized hydrodynamic injections.
2. **Hydrogel in dusty form** is used by companies specializing in hydro-sowing.

Tab. 1 Polymeric hydrogels TetraHydrogel Aqua

<table>
<tr><td>Nr polimeru</td><td>Opis</td><td></td></tr>
<tr><td>1</td><td>Hydrogel 1 dusty</td><td rowspan="2">Crosslinked acrylic polymer:
moisture (w %): 6-10 /
rate of absorption: 0,5-2 h</td></tr>
<tr><td>2</td><td>Hydrogel 2 granular</td></tr>
</table>

Polymers TetraHydrogel Aqua they were made available for free by Terra Group Alpha. Data to be downloaded from the website http://www.hydrogel.pl/index.html

Manual for the exercise

1. Weigh in a weighing dish on an analytical balance, 0.5 g of polymers 1 and 2.
2. Sprinkle them into 50 ml glass cylinders and describe with numbers 1 and 2 as polymers used.
3. Prepare stopwatch.
4. Add 25 ml of distilled water to the cylinders, mix the contents of the cylinder with a glass rod (the baguette can be rinsed with water to the cylinder if necessary) and add distilled water if necessary
5. Turn on the stopwatch and watch the process in the cylinder. You can record a movie.
6. Every 30 seconds mark the level of the deposit on the cylinder (observe diligently for 5 minutes) and then every 10 minutes - also mark the bed level in the cylinder. Take note of the observation and height of the deposit.Opisać zauważone zjawisko i porównać oba polimery.
7. Calculate the bulk swelling in g water / g dry polymer and%.

1.2. Tests on swelling

Tab. 2

No.	Description	Skrót	Matryca polimerowa
3	Polymeric adsorbent	XAD 4	Crosslinked copolymer: styrene/divinylbenzene
4	**Cationite** Cation-exchange resin	C102	Crosslinked copolymer: polyacrylate with carboxylic groups
5	**Anionite** Aniono wymienna żywica polimerowa	A400	Crosslinked copolymer (styrene/divinylbenzene) with strong-base amino groups

Polimers C102 i A400 were donated by Purolite,

AMBERLITE ™ XAD - 4 is a polymeric adsorbent in the form of white insoluble beads. It is a non-ionic crosslinked polymer based on a copolymer of styrene and divinylbenzene, which derives its adsorptive properties from a patented structure (containing a continuous polymer phase and a continuous pore phase), a large surface area and the aromatic character of its surface (Fig. 1).

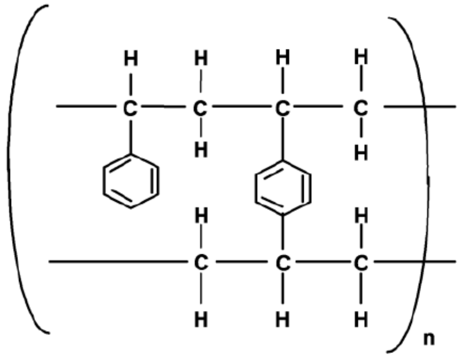

Fig. 1

XAD-4

The highly crosslinked structure gives AMBERLITE XAD 4 excellent physical, chemical and thermal stability. The AMBERLITE XAD 4 polymer adsorbent can be used in repeated cycles, in column or batch mode, for the adsorption of hydrophobic molecules from polar solvents or volatile compounds. The characteristic pore size distribution makes AMBERLITE XAD 4 an excellent sorbent for concentrating organic substances of relatively low molecular weight in aqueous solutions.

Purolite A400

Anion-exchange resin of standard size and gel structure. The main application of A 400 is the processes of water demineralization and condensate treatment. It is characterized by high exchange capacity and allows for low silica slip.

Purolite C104

Cation exchange resin with standard grain size and structure, hydrogen form. The unique structure of the polyacrylic matrix and the carboxyl-functional groups contained therein ensures high, usable chemical capacity of the ion exchanger and very good kinetics of work. The main application of ion exchanger is the removal of Ca and Mg ions derived from bicarbonate alkalinity (carbonate hardness) of water.

Manual for determining water uptake

1. Swollen polymers 3, 4 and 5 should be collected from PE containers (in an amount of about 4 grams) and placed in the nets with a dense mesh, balanced and centrifuged (balanced means to place on the opposite arms the vials with the same masses).
2. Then centrifuge for 5 minutes in a laboratory centrifuge at 3,000 rpm to get rid of liquid from the interstitial spaces.

NOTE: students spin one swollen polymer and then divide it into subgroups.

Note the data in Tab. 3.

3. In the meantime, weigh on the analytical balance 6 weighing bottles with lids (2 for each polymer) and describe (example description for polymer 3: 3-1, 3-2)
4. After centrifugation, place the wet polymers in two weighed weighing bottles.
5. Weigh the wet polymers with the dishes.
6. Then leave the dishes with wet polymers in a laboratory dryer where the temperature is 60 ° C for 1 hour.
7. After 1 hour cool the vessels with polymers and re-weigh them.
8. Then set aside for drying at room temperature.
9. At the next class, weigh the dishes again and make calculations.

Water absorption, marked as **W**, is a parameter that determines the amount of water in grams that can absorb 1 gram of dry polymer (sorbent, ionite). It is the ratio of the difference of the wet and dry polymer masses to the weight of the dry polymer. It is expressed in grams of water contained in the polymer to a mass of 1 gram of dry polymer.

$$\mathbf{W} = \frac{\mathbf{m_{mokry} - m_{suchy}}}{\mathbf{m_{suchy}}} = \frac{\mathbf{m_{mokry}}}{\mathbf{m_{suchy}}} - \mathbf{1} \left[\frac{g\,H_2O}{g}\right],$$

gdzie:

W – chłonność wody, $\left[\frac{g\,H_2O}{g}\right]$

m_{mokry} – masa mokrego jonitu, [g]

m_{suchy} – masa suchego jonitu, [g].

gdzie:

W – water uptake [g H_2O/g polimeru]

$\mathbf{m_{mokra}}$ – wet mass of swollen polimer after centrifugation [g]

$\mathbf{m_{sucha}}$ – dry mass of polymer [g]

Content of polimer in a swollen gel: $\% = \frac{m_{sucha}}{m_{mokra}} \times 100\%$

Tab 3. Calculations of swelling

Polimer	Masa naczynka	Masa naczynka z odwirowanym polimerem, g	Masa mokrego polimeru, g	W g wody/g polimeru	W dane prod	%	% dane prod.
3-1							
3-2							
3							
4-1							
4-2							
4							
5-1							
5-2							
5							

1.3. Evaluation of bed swelling in ion exchange columns

1. Pour 50 ml of distilled water into packed ion-exchange columns with polymers 4 and 5
2. Unscrew the tap and slowly approx. 1 drop for 15 seconds set the flow
3. Check the pH of the leakage with the universal paper
4. Mark the bed height
5. In the meantime, calculate the volume of the bed in the column
6. Add to the cup 4 (cationite) a 0.05 M NaOH solution into the cup
7. Add an 0.05 M HCl solution to the cup (anion)
8. Observe the work of the deposit
9. Calculate the bed volume after pouring 100 ml of solutions
10. Wash the flasks with 100 mL distilled water
11. Explain the observed phenomenon