DLF
DYDAKTYCZNE LABORATORIUM FIZYCZNE

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UNIWERSYTET GDAŃSKI

Experiment 19

Determining the dipole moments of polar molecules in the ground state

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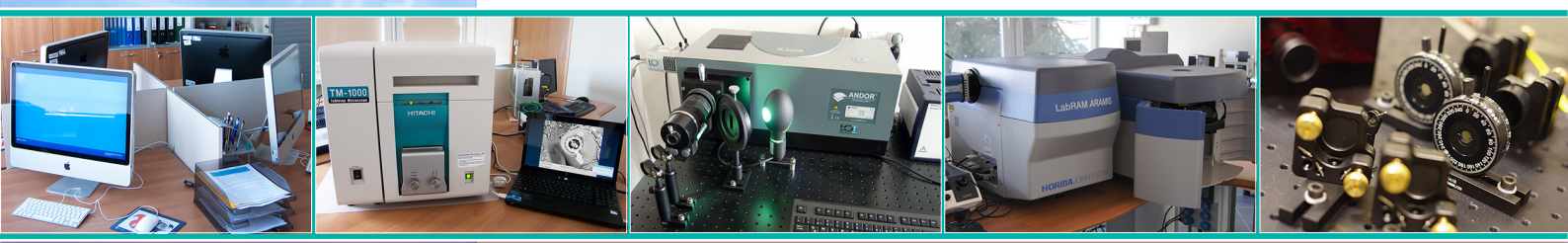


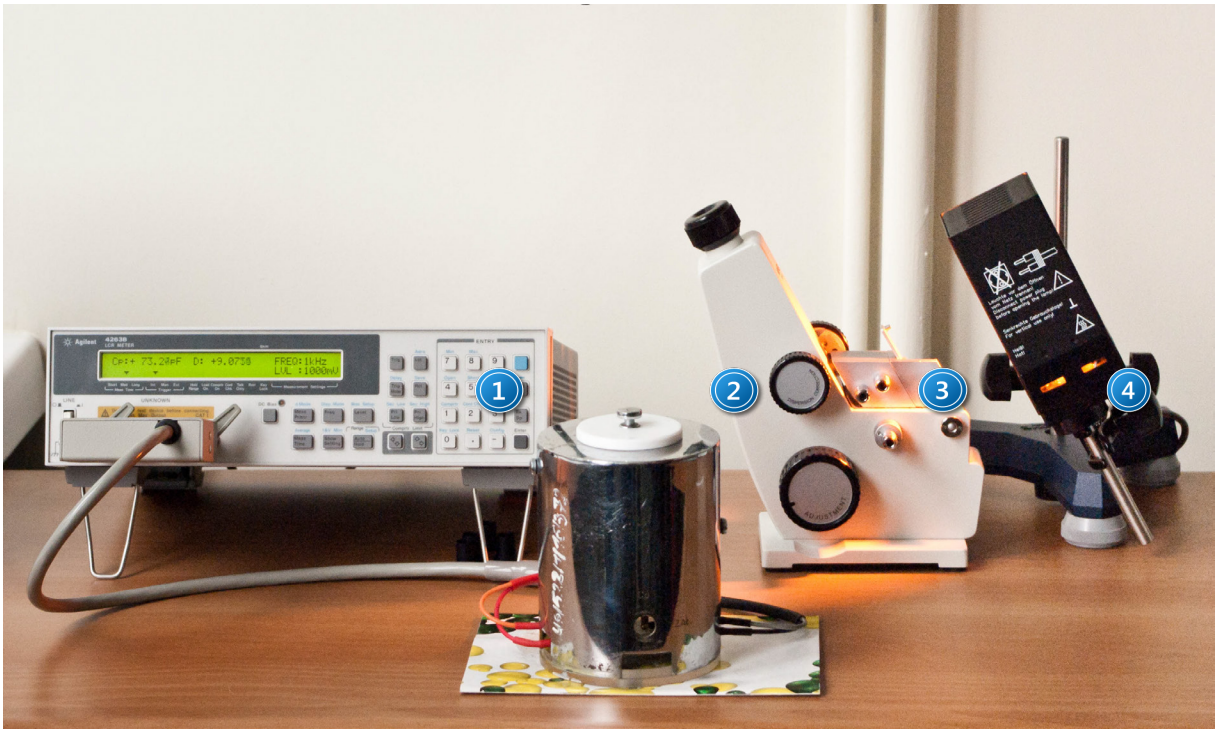
I. Background theory.

1. Physical nature of molecular bonds.
2. Electric dipole moments of molecules.
3. Electric polarisability of molecules.
4. Material properties of a medium in an electric field:
   a) intensity and induction of the electric field;
   b) dielectric medium;
   c) electric polarisation;
   d) electric susceptibility of a substance.
5. Dielectric polarisation in a constant electric field:
   a) induced dipole moment;
   b) polarisability;
   c) local Lorentz field;
   d) Clausius – Mossottiego equations.
6. Mechanisms of dielectric polarisation:
   a) electron polarisation;
   b) ionic polarisation (atomic);
   c) polarisation orientation (dipole);
   d) molar refraction;
   e) Lorenz – Lorentz model;
   f) Debye equation.
7. Dielectric in a varying electric field.
8. Experimental methods of determining molecular dipole moments.
9. Refractive index and its relationship with the dielectric constant of a medium.
10. Construction of an Abbe refractometer.
11. Measuring refractive indices using an Abbe refractometer.
12. Determining dipole moments in dilute solutions based on Debye theory.

II. Experimental tasks.

1. Prepare solutions of DMSO (dimethyl sulfoxide) in dioxane at concentrations: 0.02, 0.04, 0.06, 0.08 and 0.1 mole fraction using the table in *Appendix B*.

   A description of the physical – chemical properties of DMSO and of dioxane are found in *Appendix A.*
2. Refer to the setup shown in *Picture 1*.
3. Turn on the sodium lamp (4 in *Picture 1*) direct its light onto the Abbe refractometer prism system (3 in *Picture 1*).
4. Measure the refractive index of the illuminated liquid.
5. Wash and dry the measuring capacitor (2 in *Picture 1*).
6. Turn on the RLC bridge using the LINE button (1 in *Picture 2*), connect the capacitor and tighten the capacitor cover lock.



Picture 1. Experimental setup: 1- RLC bridge; 2 - capacitor; 3 – Abbe refractometer; 4 – sodium lamp.

7. Calibrate the meter. To do this, short-circuit the cable ends (shorting + to +) and click on the additional function button on the bridge panel (3 in *Picture 2*), then press the SHORT button (4 in *Picture 2*) and confirm with Enter (5 in *Picture 2*).
8. Measure the capacitance of the empty capacitor.
9. Pour the solvent into the condenser, and record the capacitance of the capacitor with pure solvent.
10. Pour each prepared solution in succession into the capacitor and measure its capacitance.

Picture 2. View of the RLC bridge front panel: 1 – switch; 2 - wire terminal; 3 – additional function button; 4 – SHORT button; 5 – ENTER button.

11. Calculate the dielectric permittivity of the test solutions.
12. Plot a graph of molar polarisation of the test solution as a function of concentration.
13. Calculate the molecular dipole moments of the test solution in the ground state using the Debye equations.
14. Compare the calculated values of dipole moments with the given data.

III. Apparatus.

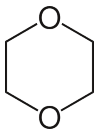
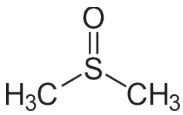
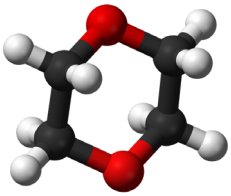
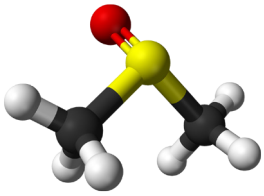
1. RLC bridge.
2. Measuring capacitor.
3. Abbe refractometer.
4. Sodium lamp.
5. Stand.
6. Beaker.

IV. Literature.

1. R.P. Feynman, R.B. Leighton, M. Sands – "*The Feynman Lectures on Physics*", Vol.2. Parts 1 & 2, Addison – Wesley , 2005.
2. A.P. Arya – "*Fundamentals of Atomic Physics* ", Allyn & Bacon, Inc., Boston 1971.
3. G. Barrow – "*Physical Chemistry*", McGraw Hill, 1996.

Appendix A

Physical – chemical properties of DMSO and 1,4 - dioxane

Name	**1,4 – Dioxane**	**DMSO**
Chemical formula	$C_4H_8O_2$	$(CH_3)_2SO$
		
		
Form	liquid	liquid
Colour	colourless	colourless
Odour	slightly aromatic	none
Molecular weight	88,10	78,133
Density	1,03 g/cm^3 (w 20 ^{O}C)	1,1 g/cm^3 (w 20 ^{O}C)
pH	6-8	No data
Melting point	11 ^{O}C	18,5 ^{O}C
Boiling point	101 ^{O}C	189 ^{O}C
Ignition temperature	375 ^{O}C	300 ^{O}C

Appendix B

Table helpful in preparing solutions of DMSO in dioxane with a concentration in mole fractions given in II.1.

1,4 - Dioxane					
C	**M [g/mol]**	**density [g/ml]**	**mass [g]**	**V_1 [ml]**	**V_2 [ml]**
0,99	88,11	1,03	87,22	84,36	21,09
0,98	88,11	1,03	86,34	83,50	20,88
0,97	88,11	1,03	85,46	82,65	20,66
0,96	88,11	1,03	84,58	81,80	20,45
0,95	88,11	1,03	83,70	80,95	20,24
0,94	88,11	1,03	82,82	80,10	20,02
0,93	88,11	1,03	81,94	79,24	19,81
0,92	88,11	1,03	81,06	78,39	19,60
0,91	88,11	1,03	80,18	77,54	19,38
0,90	88,11	1,03	79,29	76,69	19,17

DMSO					
C	**M [g/mol]**	**density [g/ml]**	**mass [g]**	**V_1 [ml]**	**V_2 [ml]**
0,01	78,13	1,10	0,78	0,71	0,18
0,02	78,13	1,10	1,56	1,42	0,36
0,03	78,13	1,10	2,34	2,13	0,53
0,04	78,13	1,10	3,13	2,84	0,71
0,05	78,13	1,10	3,91	3,55	0,89
0,06	78,13	1,10	4,69	4,26	1,07
0,07	78,13	1,10	5,47	4,97	1,24
0,08	78,13	1,10	6,25	5,68	1,42
0,09	78,13	1,10	7,03	6,39	1,60
0,10	78,13	1,10	7,81	7,10	1,78