A STUDY OF THE BEHAVIOR OF PECTIN SUBSTANCES IN AQUEOUS SOLUTIONS BY THE LIGHT-SCATTERING METHOD

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The study of the behavior of polysaccharides in aqueous solutions by the light-scattering method gives information on the structure and the physicochemical and biological properties of these biopolymers [1-3]. The present paper gives the results of a study of the action of various factors on the dimensions of the particles formed by pectin substances in aqueous solutions. The subjects for the investigation were the pectin of seaweeds (zosterin [4]), the pectin of ginseng (panaxan [5]),and their fragments (Table 1). The behavior of the pectins in solutions depends on the proportion of uronic acids in their carbohydrate chains and on the proportion of methoxy groups, which affect the solubility of the polysaccharides and the nature of their intermolecular interactions (Tables 1 and 2), and also on various additives.

In aqueous solutions at 20°C, the polysaccharides exist in the form of high-molecular-weight aggregates. Sodium chloride, ammonium hydroxide, urea, and Tween-20 cause the dissociation of the aggregates, especially at an elevated temperature (see Table 2), which is shown [6] by the negative values of the second virial coefficient in the Debye equation [7] by means of which the calculations were performed.

Thus, by varying the conditions it is possible to affect the state of pectin substances in aqueous solutions.

EXPERIMENTAL

The Rayleigh scattering of light was measured on an FPS-2M photoelectric light-scattering instrument. The relative intensities of the light were obtained by the direct measurement of the photocurrent by means of an electrophotometric scheme permitting the compensation of the fluctuations of the source of light and the automatic recording of the signal. The constant of the apparatus was found from calibration measurements in benzene. The increment of the refractive index was measured in white light on an ITR-2 interferometer and in monochromatic light on a differential refractometer with a thermostated cell. The refractive index was determined on an IRF-23 refractometer. The solutions of the pectin substances studied were prepared directly in the cells for light scattering (volume 50 cm^3) by the method of successive dilutions. The concentration of the polysaccharides in the solutions was $1 \cdot 10^{-5}$ to $2 \cdot 10^{-3}$ g/ml. Debye's formula [7, 8] was used for the calculation of the values of the weight-average molecular weights ($\bar{M}_W$). For particles with

TABLE 1. Analytical Figures for the Polysaccharides Studied

Polysaccharide	Amount, %		
	uronic acid	methoxy groups	$\bar{M}_n \times 10^{-3}$
Zosterin	60	1,5	78
Apiogalacturonan (AGU)	39,6	1,5	22
Zosterin galacturonan (ZGU)	98,3	1,7	18—22
Panaxan	60	5,0	25—29
Panaxan galacturonan (PGU)	100	5,9	18—20

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TABLE 2. Light-Scattering Behavior of Aqueous Solutions of the Pectins

Solvent	Temp. of the solution, °C	Second virial coeff., A_2	$\bar{M}_W$
	Zosterin		
Water	20	$2{,}2\cdot10^{-4}$	$3{,}0\cdot10^{8}$
	85	$1{,}6\cdot10^{-4}$	$1{,}0\cdot10^{7}$
Urea 1 M	20	$1{,}9\cdot10^{-4}$	$3{,}0\cdot10^{8}$
0.3 M	85	—	$1{,}0\cdot10^{6}$
Tween-20 0.002%	85	$-0{,}6\cdot10^{-3}$	$1{,}9\cdot10^{5}$
0.004%	85	$-3{,}0\cdot10^{-3}$	$1{,}2\cdot10^{5}$
	AGU		
Water	20	$4{,}5\cdot10^{-2}$	$1{,}8\cdot10^{5}$
Urea 0.2 M	20	$4{,}5\cdot10^{-2}$	$1{,}8\cdot10^{5}$
0.2 M	70	$-3{,}2\cdot10^{-2}$	$2{,}1\cdot10^{4}$
	ZGU		
Water	20	$4\cdot10^{-5}$	$6{,}2\cdot10^{7}$
NaCl 0.01 M	20	0	$3{,}1\cdot10^{7}$
NH_4OH 0.19 M	20	$-5{,}2.10^{-3}$	$1{,}3\cdot10^{5}$
Urea 0.01 M	20	$-1{,}9\cdot10^{-3}$	$1{,}3\cdot10^{5}$
	Panaxan		
NaCl 0.3 M	20	$4\cdot10^{-2}$	$9{,}0\cdot10^{5}$
2 M	20	—	$3{,}3\cdot10^{4}$
	PGU		
NaCl 0.1 M	20	$2{,}8\cdot10^{-2}$	$1{,}0\cdot10^{6}$
2 M	20	$-5{,}0\cdot10^{-3}$	$1{,}9\cdot10^{5}$
NH_4OH 0.19 M	20	—	$1{,}7\cdot10^{4}$

a high value of $\bar{M}_W$ the results were interpreted by the double-extrapolation method [9]. The number-average molecular weight $\bar{M}_n$ was determined as described previously [3].

SUMMARY

1. Pectin substances form high-molecular-weight aggregates in water.

2. When the temperature is raised, and also when sodium chloride, ammonium hydroxide, urea, and Tween are added, dissociation of the polysaccharide aggregates takes place (at given concentrations) – in a number of cases to particles with similar values of the weight-average and number-average molecular weights.

LITERATURE CITED

1. F. G. E. Pautard and H. Zola, Biopolymers, 6, 629 (1968).
2. R. L. Cleland, Biopolymers, 6, 1519 (1968).
3. A. K. Dzizenko, V. D. Sorochan, T. I. Prudnikova, and Yu. S. Ovodov, Izv. Akad. Nauk SSSR, Ser. Khim., 1969, 2815.
4. Yu. S. Ovodov, R. G. Ovodova, O. D. Bondarenko, and J. N. Krasikova, Carbohyd. Res., 18, 311 (1971).
5. T. F. Solov'eva, L. V. Arsenyuk, and Yu. S. Ovodov, Carbohyd. Res., 10, 13 (1969).
6. C. Tanford, Physical Chemistry of Macromolecules, Wiley, New York (1961).
7. P. Debye, J. Appl. Phys., 15, 338 (1944).
8. K. A. Stacey, Light Scattering in Physical Chemistry, Butterworth, London (1956).
9. B. Zimm, J. Chem. Phys., 46, 1093, 1099 (1948).