

The refractive index of inulin solutions

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Inulin - a heteropolysaccharide found in a range of Compositae (thistle family) plants, in particular in Jerusalem artichokes, consists of fructose radicals, bonded in 2,1- glycoside bonds. It can be used as a base raw material when obtaining fructose. However, the physical and chemical properties of this valuable natural product have not been studied adequately up till now. The particular point of interest is the study of the physical and chemical properties of inulin which can be used to determine the degree of purity of this compound and its solutions.

The establishment of the relationship between the refractive index of inulin solutions and their concentrations and temperatures with a view to subsequent use of the obtained data to determine the control of the purity of the products is of current interest, since the methods of spectrophotometric and chromatographic analysis of inulin described in the literature are lengthy and laborious [1,2].

Experimental data showed that the refractive index naturally drops for fixed values of concentrations of test solutions when the temperature is increased (Fig 1). The variation in concentrations of solutions influences the value of the refractive index (n) to an even greater extent. The relationship between the n values and the concentrations is directly proportional in the case of fixed temperature values (Fig 2).

A mathematical definition is obtained of the relationship between n and the two factors - concentrations and temperatures of the inulin solutions simultaneously. An experimental and statistical model of this relationship was derived as an intercept of the Taylor Series using methods of optimum planning of the experiment [3,4]. Results of the full factorial experiment type 2^2 and basic data from the mathematical analysis are presented in tables 1 and 2.

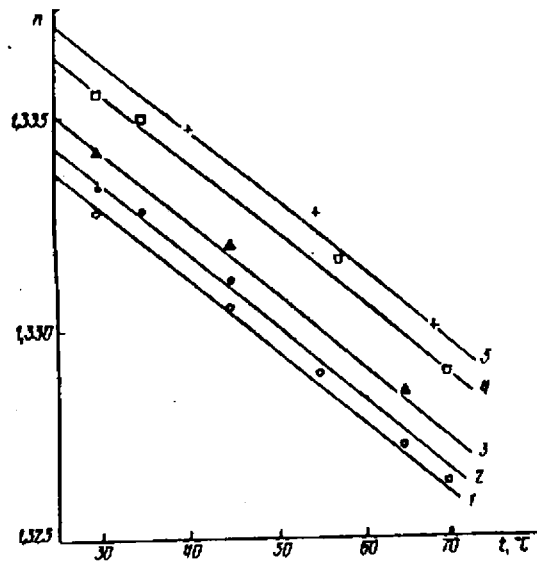


Fig 1. The relationship between the refractive index n of the inulin solutions and temperature $n=f(t)$

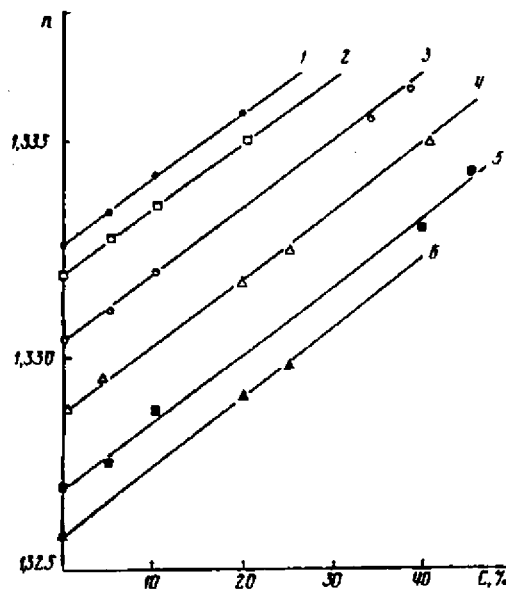


Fig 2. The relationship between the refractive index of the inulin solutions and the concentrations, $n=f(c)$.

Calculations: $S_j^2=0$ $G_p=0$ $G_p < G_r$
 $S_j^2=0$ $S_y^2=0$ $S_{0j}^2=0$ $F_p < F_r$

where X_i = factors (in coded variables);
 x_i = factors (in physical variables);

- y^p - variable state (experimental value);
- y^c - variable state (calculated value);
- G_p - calculated value of the Cochran criterion;
- G_r - tabulated value of the Cochran criterion;
- S_j^2 - evaluation of the variance for a series of parallel experiments;
- S_r^2 - evaluation of the variance of reproducibility;
- S_m^2 - evaluation of the variance of the mean value;
- S_{oi}^2 - variance of adequacy;
- F_p - the Fisher criterion (calculated value);
- F_r - the Fisher criterion (tabulated value).

The notations are taken as per [3,4].

The absolute value of the coefficients and signs (-, +) in front of them in the resulting regression equation confirm the qualitative relationship, established previously experimentally, between the refractive index and the influencing factors.

Table 1

Denomination	X_1 °C	X_2 %	Calculated regression equation in coded variables
Datum level (o)	55	2.5	$Y = 1.3322 - 1.625 \cdot 10^{-3} X_1 + 1.975 \cdot 10^{-3} X_2 \quad (1)$
Variation interval (Δ)	10	1.5	
Upper level (+)	65	4.0	
Lower level (-)	45	1.0	

Table 2

Experiment	Plan		Variable state	
	X ₁	X ₂	y ³	y ^p
1	-	-	1.3318	1.3318
2	+	-	1.3286	1.3286
3	-	+	1.3356	1.3356
4	+	+	1.3325	1.3325

Comparison of the absolute value of the coefficient makes it possible to confirm that the concentration influences the value n to a larger extent, than temperature (coefficient $1.975 \cdot 10^{-3} > 1.625 \cdot 10^{-3}$). On the other hand, judging by the signs in front of these coefficients, the increase in concentration leads to an increase in the value of n (+ sign), while an increase in temperature involves a reduction in the value of n (- sign).

The conversion from coded variables to physical with the use of known functions between them:

$$\lambda_i = \frac{x_i - x_{0i}}{\Delta x_i} \quad (2)$$

leads to a regression equation, expressed in physical variables:

$$n = 1.3378 - 1.625 \cdot 10^{-4}t + 1.3166 \cdot 10^{-3}C \quad (3)$$

The latter equation can be used for direct processing of numerical experimental data.

In order to determine the degree of purity of the inulin solutions (S), experimentally obtained values of the refractive index of the solutions (n_3) were compared with those calculated (n_p) according to equation (3):

$$S = \frac{n_3}{n_p} \cdot 100\% \quad (4)$$

The method developed to control the purity of the inulin is simple in the design of apparatus, sufficiently accurate and in contrast to the methods

described in the literature does not require additional use of expensive analytical reagents.

References

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