

# THE INFLUENCE OF SUBSTRATE COMPOSITION ON THE PHYSICOCHEMICAL PROPERTIES OF HYDROGELS WITH CHITOSAN

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## **Abstract**

*The aim of the study was to evaluate the effect of Carbopol 934 P and PVP K 90 on the rheological properties of chitosan gels. Hydrogels were prepared with hydrocortisone containing chitosan, Carbopl 934P, PVP, propylene glycol-1,2 or polyethyleneglycol 400 and glycerol. Addition of polymers had positive influence on the dispersion of hydrogels. The studied gels have thixotropic properties, their viscosity increases with the increase of the concentration of polymers. Increase of the content of polyvinylpyrrolidone K 90 and Carbopol 934 P increases the consistence, gels are more firm and cohesive. Gels with 5 % chitosane, 15% polyvinylpyrrolidone K 90 and Carbopol 934 P in the presence of additives have prolonged half release period of hydrocortisone.*

**Key words:** *hydrogels, chitosane, Carbopl 934P, PVP, rheological parameters, pharmaceutical availability*

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## **1.Introduction**

Hydrogels are carriers of many drugs applied on the skin and they are used to produce preparations administering in other forms. Used in dermatology, hydrogels ensure effectiveness of the drug substance [1-4]. Chitosan is often used for the preparation of dermatological gels as a drug carrier of anti-inflammatory and analgesic properties. Favorably affects the application properties and the pharmaceutical availability of many drugs [5-8].

The aim of the study was to evaluate the effect of Carbopol 934 P and PVP K90 on the physicochemical properties of chitosan gels.

## **2. Materials and methods**

### **2.1. Materials**

Hydrocortisone (Polfa Pabianice, Poland), Carbopol 934 P (BF Goodrich, speciality Chemicals Division, Ohio), polyvinylpyrrolidone K 90 (Fluka AG), propylene glycol-1,2 (Sigma-Aldrich GmbH Germany), polyethylene glycol 400 (Loba Feinchemie, Fischamend), glycerol (Chempur Poland), chitosan type 652 France, purified water to Polish Pharmacopoeia 10<sup>th</sup> Ed.

### **2.2. Preparation of hydrogels**

Chitosane hydrogels at 5% concentration and 10 - 15% PVP or 1-3% Carbopol containing 1% hydrocortisone, 1,2-propylene glycol or polyethylene glycol 400, glycerol and distilled water were prepared *ex tempore*. The composition of the investigated gels is presented in Table 1.

### **2.3. Consistency test**

TPA test of texture profile analysis was performed with Exponent Stable Micro Systems texture analyzer TAXT plus. The texture of the gel was set by examining the hardness, consistency and density, back extrusion method, which consists of the process of retracting extrusion. Test parameters: force of 2 g, speed of 2 mm/s, distance of 20 mm, diameter disc 35 mm [9].

### **2.4. Dynamic viscosity test**

Was carried out using a rotational viscosimeter Rheotest 2 Medingen Dresden. The determinations were performed in I a range on K-1 cone with the diameter of 36mm, at 37 °C. The values of the shear stress and viscosity were calculated from measurements [3].

### **2.5. Examination of pharmaceutical availability of hydrocortisone**

The process of hydrocortisone release from hydrophilic base was carried out according to the Polish Pharmacopoeia 10<sup>th</sup> Ed. The concentration of hydrocortisone was determined with the Jasco V-650 spectrophotometer at wavelength of 241 nm according to Polish Pharmacopoeia 10<sup>th</sup> Ed.

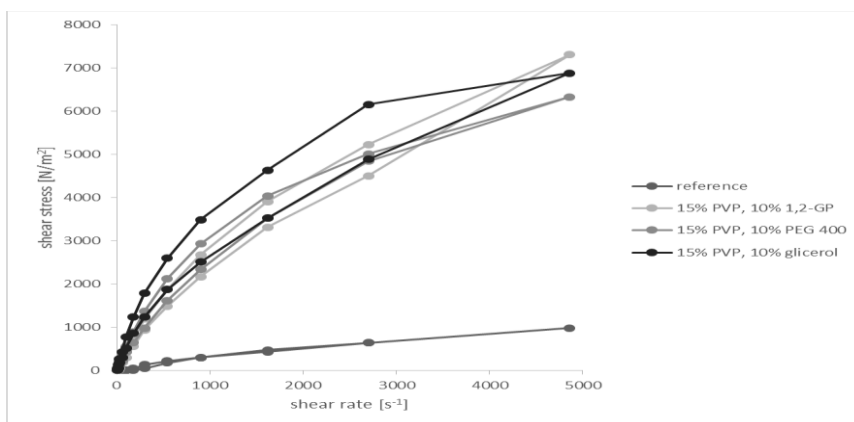
## **3. Results and discussion**

The study of influence of polyvinylpyrrolidone K 90 and Carbopol 934 P on physicochemical properties of hydrogels 5% chitosan gel in the presence of additives propylene glycol, polyethylene glycol 400 and glycerol.

The texture of the gel was set by examining the hardness, consistency and density.

Increase of the content of polyvinylpyrrolidone K 90 and Carbopol 934 P increases the consistency hydrogels on the basis chitosane, gels are more firm and cohesive.

Hardness gels with 5% chitosan and 15% PVP, 10% propylene glycol-1,2 or PEG 400 respectively from 40,27 to 44,99 g and 11,65 g for reference gels. The gels with Carbopol have a greater hardness than made from PVP. Consistency of the gels with PVP is from 203,72 to 244,48g and 2692,86 to 3000,03g for Carbopol. The highest density 350,9 gs shows gel containing Carbopol and 10% glycerol, formulation with PVP and PEG 15,51 gs. Carbopol or polyvinylpyrrolidone K 90 and hydrophilizing substances are influencing on increasing shear stress of gels with 5% chitosan (Fig. 1), with shear rate from 11,10 to 4860,00 D [ s<sup>-1</sup>].



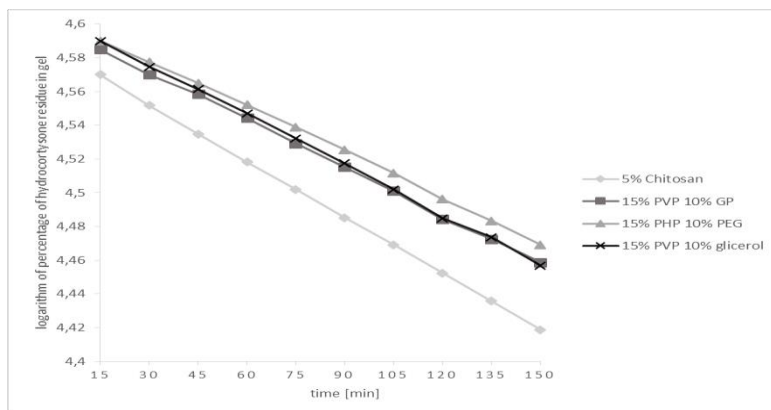
**Figure 1.** Flow curves of hydrogels on the basis 5% chitosane containing PVP.

With the addition of 15% PVP and 10% PEG, glycerol or propylene glycol-1,2 is from 6332,5 to 7310,0 N/m<sup>2</sup>. The shear stress for hydrogels from 3% Carbopol was lower than gels containing 15% PVP. Shear stress in the presence of Carbopol, glycerol and propylene glycol-1,2 is from 6502,5 to 7055,0 N/m<sup>2</sup>, which were presented in Table 1.

**Table 1.** Viscosity parameters of hydrogels determined at 37°C and shear rates 4860,00 [s<sup>-1</sup>]

Composition of the gels	Shear stress N/m <sup>2</sup>	Viscosity mPa s
5% Chitosan, 15% polyvinylpyrrolidone, 10% propylene glycol-1,2	7310,00	150,41
5% chitosan, 15% polyvinylpyrrolidone, 10% polyethylene glycol 400,	6332,50	130,30
5% chitosan, 15% polyvinylpyrrolidone, 10% glycerol,	6885,00	141,67
5% chitosan, 3% Carbopol 934 P, 10% propylene glycol-1,2	7055,00	145,16
5% chitosan, 3% Carbopol 934 P, 10% glycerol	6502,50	133,80
5% chitosan	977,50	20,11

The study of pharmaceutical availability was performed using the method from the Polish Pharmacopoeia 10<sup>th</sup> Ed. The release process of all of the formulations follows a first order kinetics. Logarithm from the percentage of hydrocortisone as function of time is presented in Figure 2.



**Figure 2.** Influence of 15% polivinylpyrrolidone K 90 additive on hydrocortisone release from 5% chitosane hydrogels

Gels with 5 % chitosane, 15% polyvinylpyrrolidone K 90 and Carbopol 934 P in the presence of additives have prolonged half release period of hydrocortisone, release process from 10,4 h to 27,5 h, which were presented in Table 2. Analysis of correlation and test NIR and Brown-Forsythe showed that the results are statistically significant.

**Table 2.** Release rate constants [K], semiliberation rates  $T_{0,5}$  of hydrocortisone from hydrogels on the basis chitosane.

Composition of the gels	Release rate constants K [h <sup>-1</sup> ]	Semiliberation rates $T_{0,5}$ [h]	Correlation coefficient
5% Chitosan, 15% polyvinylpyrrolidone, 10% propylene glycol-1,2	0,0538	12,89	0,9945
5% chitosan, 15% polyvinylpyrrolidone, 10% polyethylene glycol 400,	0,0519	13,36	0,9968
5% chitosan, 15% polyvinylpyrrolidone, 10% glycerol,	0,0566	12,25	0,9914
5% chitosan, 3% Carbopol 934 P, 10% propylene glycol-1,2	0,0262	26,44	0,9953
5% chitosan, 3% Carbopol 934 P, 10% glycerol	0,0253	27,50	0,9942
5% chitosan	0,0667	10,40	0,9974

The addition of polyvinylpyrrolidone K 90 and Carbopol 934 P gels based on chitosane affects the time diversity of the half-release of drug substances and profit on the rheological properties which facilitates the preparation, application and spreading on the skin.

#### **4. Conclusions**

1. Increase of the content of polyvinylpyrrolidone K 90 and Carbopol 934 P increases the consistence, gel with 5 % chitosane are more firm and cohesive. The most favorable results in terms of studied parameters are for hydrogels based on Carbopol 934P.
2. Gels with 5 % chitosane, 15% polyvinylpyrrolidone K 90 and Carbopol 934 P in the presence of additives have prolonged half release period of hydrocortisone.

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