

**Properties of natural heteropolysaccharide xanthan in aqueous** solutions and its compositions with cobalt nanoparticles

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#### Introduction

Natural polysaccharides are well known for their biocompatibility, non-toxicity and biodegradability. Among them, the heteropolysaccharide xanthan of microbial origin plays an important role in food and non-food industries as a matrix for tablets, nano- and microparticles, hydrogels. Due to its structure, xanthan can generate various types of interactions with other small molecules and macromolecules, forming interesting nano- and microstructures. In the present work, a xanthan sample produced by the bacterium Xanthomonas campestris was characterized in detail and used as a template for the in situ synthesis of cobalt nanoparticles (CoNPs) in an aqueous medium.

#### Methods

The molecular weight of xanthan (1170 kDa) and its electrochemical properties, viscosity behavior and structure in aqueous and aqueous/Co-salt solutions were determined using viscometry, potentiometric titration, FTIR spectroscopy and TEM. The process and products of the borohydride reduction of Co-salt in xanthan solutions were studied depending on the concentration of matrix and metal salt (and reducing agent) using photography, FTIR spectroscopy and TEM.

## Characterization of the molecular parameters of xanthan





а

10

calculated from titration data of xanthan water/salt solution

### **Xanthan interaction with Co-salt**



FTIR spectra of xanthan (a) and its compositions



Hydrodynamic parameters of xanthan in aqueous and aqueous/saline solutions

Matrix	T=25 °C	
	[η], m <sup>3</sup> ·kg <sup>-1</sup>	k
Xanthan	1,29	4,26
Co <sup>2+</sup> /Xanthan	1,38	0,78

Reduced viscosity of xanthan solutions -1 and its mixtures with Co salts -2 at T=25 °C

#### Xanthan solutions as the effective matrixes for the *in situ* synthesis of CoNPs



with (b) Co salts





4000

#### 1000 2000 3000 **Compositions of CoNPs/Xanthan Composition of CoNPs/Xantan/Ethylene glycol** ν, CM FTIR spectra of xanthan composition with CoNPs (c) **Borohydride reduction of cobalt ions:**

 $\text{Co}^{2+}+2\text{BH}_{4}-+6\text{H}_{2}\text{O}\rightarrow\text{Co}^{\circ}+7\text{H}_{2}+2\text{B}(\text{OH})_{3}$  $2Co^{2+} + 2BH_4 + 2H_2O \rightarrow Co_2B + HBO_2 + 2H^+ + 4.5H_2$  $4Co_2B + 3O_2 = 8Co^0 + 2B_2O_3$ ;  $B_2O_3 + 3H_2O = 2B(OH)_3$ 

salt concentration 0.08÷0.32 kg·м<sup>-3</sup> concentration NaBH<sub>4</sub>/Co-ions 1÷5 xanthan concentration 0.5÷1 kg·м<sup>-3</sup>

### Conclusion

A significant excess of carboxylate groups (10.24 mol·kg<sup>-1</sup>) compared to carboxylic groups (1.29 mol·kg<sup>-1</sup>) in xanthan macromolecules was established. The absence of a polyelectrolyte effect in aqueous solutions of xanthan in a wide range of concentrations was also revealed. In the presence of Co-salt, xanthan interacted with metal ions that led to the compaction of its macro coils.

It was shown the possibility of the xanthan use as the matrix for the *in situ* synthesis of CoNPs in an aqueous medium. The influence of the concentration of xanthan matrices on the stability of CoNPs with respect to their aggregation and sedimentation, as well as on the yield of metal nanoparticles, is also shown. The resulting composition consisted of swollen xanthan coils ~47-97 nm in size containing small amorphous CoNPs ~1.3-9.8 nm in diameter.

