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## **Structural, Swelling and Water Absorption Properties of New Polymer Blends for Modern Applications**

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In this paper, fabrication of new polymer blends for water absorption in crude oil is used. The polymer blends are prepared from polyvinyl alcohol (60 wt.%) and polyethylene glycol (40 wt.%) with different concentrations of polyvinyl pyrrolidone (10, 20, 30 wt.%). The structural, swelling and water absorption properties of PVA–PEG–PVP blends are studied. The results show that both the swelling ratio and the water absorption of PVA–PEG blend increase with increase in PVP concentration. In addition, the PVA–PEG–PVP blends have good swelling and water-absorption ratio with the time.

У роботі використовується виготовлення нових полімерних сумішей для водопоглинання в сировій нафті. Полімерні суміші готуються з полівінілового спирту (ПВС; 60 ваг.%) і поліетиленгліколю (ПЕГ; 40 ваг.%) з полівінілпірролідом (ПВП) різною концентрацією (10, 20, 30 ваг.%). Досліджено структурні, набрякні та водопоглинальні властивості сумішей ПВС–ПЕГ–ПВП. Результати показують, що коефіцієнт набрякання та гігроскопічність суміші ПВС–ПЕГ збільшуються зі збільшенням концентрації ПВП. Крім того, суміші ПВС–ПЕГ–ПВП мають хороше співвідношення набрякання та водовбирання з часом.

**Key words:** polymer blend, crude oil, water absorption, swelling.

**Ключові слова:** полімерна суміш, сирова нафта, водопоглинання, набрякність.

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## 1. INTRODUCTION

The term 'hydrogel' is used to describe materials, which are three dimensional, hydrophilic, high-molecular-weight polymeric networks capable usually for imbibing large amounts of water or biological fluids or aqueous solutions within their structure near equilibrium without dissolution. The interactions responsible for water sorption by hydrogels are due to hydrophilic nature of functional groups on the polymer backbone, which can be non-ionic ( $-\text{OH}$ ,  $-\text{O}-$ ,  $-\text{NH}_2$ ,  $-\text{CONH}-$ ,  $-\text{CHO}$ ) or ionic ( $-\text{SO}_3\text{H}$ ,  $-\text{COOH}$ ,  $-\text{COONa}$ ,  $-\text{COONH}_4$ ,  $-\text{NR}_2\text{HX}$ , *etc.*), and the existence of capillary areas and differences in osmotic pressure. The forces, which make hydrogel dissolution impossible, are presented by covalent bonds between individual polymer chains, hydrophobic and electrostatic interactions. Hydrogels have numerous functional properties such as high water absorptivity, optical clarity, inherent compatibility in biological (aqueous) fluids (*i.e.*, biocompatibility), soft tissue-like behaviour, oxygen permeability and elasticity, *etc.* Because of these versatile properties, they are important in different fields including pharmaceuticals, biotechnology, agriculture, food processing and electronics. Recently many researchers have focused on modifying hydrogels with a view to enhance their water absorbency, gel strength, and absorption rate [1].

In recent years, polymeric gels are the objects of intensive studies. Highly swollen polymers or copolymers are highly hydrophilic, three-dimensional crosslinked polymeric structures, which are able to swell in the aqueous environment. Hydrogels have found numerous uses ranging from daily life applications, mainly due to their high water absorption capacity to the development of new materials for many different purposed applications. Hydrogels are inherently soft, hydrophilic, porous, and elastic polymeric systems. The use of polymer hydrogels as biopotential sorbent or carriers for the removal of the model molecules from aqueous solutions or controlled release studies of them has been continued to attract considerable attention in recent years. Hydrogels are polymers in three-dimensional network arrangement, which are able to retain large amount of water. In order to keep the spatial structure, the polymer chains are usually physically or chemically crosslinked. Due to their swelling capacity, hydrogels can be easily rinsed to remove reagents residues. On the other hand, the big water content that makes hydrogels such a special class of materials. The importance of hydrogels in the biomaterial field is justified by some unique characteristics: the elastomeric and soft nature of the hydrogels. Crosslinked polymers capable of imbibing large volumes of water have found widespread applications in bioengineering, biomedicine, and food

industry and water purification and separation process. Due to its swelling ability in water, hydrophilicity, biocompatibility, and no toxicity, hydrogels have been utilized in a wide range of biological, medical, pharmaceutical, environmental applications [2].

By the most used definition, hydrogels are polymer networks, which are capable of absorbing and retaining large amounts of water and biological fluids. The physical and chemical features of hydrogels are extremely important for choice of their specific applications. Normally, the behaviour of hydrogels depends on external conditions, in which such materials are exposed. Thus, it is important to characterize the hydrogel properties in conditions similar to that it will be applied. Important characteristic of hydrogels is the biocompatibility. Because of this, hydrogels had been applied in biomedical field. For instance, as prolonged or controlled drug delivery systems, contact lenses, biosensors, catheters, and tissue engineering and organ reconstruction scaffolds are exceedingly common. Hydrogels can be formed by either chemical or physical crosslinking process or just by entangling of polymer chains. Galactomannan, dextran, alginate, pectin, and chondroitin sulphate are good examples of natural polymers applied on hydrogel formulations. Among the synthetic ones, polyvinyl alcohol (PVA), polyhydroxyethyl methacrylate (polyHEMA), polyethylene oxide (PEO) and poly-*N*-isopropyl acrylamide (PNIPAAm) may be cited from a plenty of others [3].

PVA is a non-toxic, water-soluble synthetic polymer and has good physical and chemical properties and film-forming ability. The use of this polymer is important in many applications such as controlled drug delivery systems, membrane preparation, recycling of polymers and packaging. Studies of the mechanism of dissolution and changes in crystallinity and swelling behaviour of PVA and its physical gel-forming capabilities have been carried out. PVA has bioinertness, and it has many uses in medical applications such as artificial pancreas, haemodialysis, nanofiltration, synthetic vitreous and implantable medical device. Antithrombotic property, cell compatibility, blood compatibility and biocompatibility of PVA have been studied extensively [4]. There are several studies of different polymer blend [5–7] like PVA and its blends [8–15]. Polyvinyl pyrrolidone (PVP) is a well known biologically and eco-friendly polymer and has been developed for biomedical applications. To improve its mechanical properties, PVP is usually blended with other polymers, which also enhances its biocompatibility and water uptake. It has been pointed out that polymers or copolymers containing carboxylic acid groups are highly desirable in biomaterials as such groups represent functionality useful for yielding a wide variety of biomedical products. The swelling of hydrogels bearing weak acid moieties depends on the acid content in the hydrogel, as well as on several oth-

er variables such as the crosslinking density, pH, and ionic strength. Polymer blends are aiming to bring together different polymers completing each other favourable properties. Blending different polymers and yet conserving their individual properties in the final mixture is an extremely attractive inexpensive and advantageous way of obtaining new structural materials. The advantages of polymer blend systems for controlled release applications may include easy fabrication of devices, manipulation of device properties (hydration, degradation rate and mechanical strength), drug loading and utilization of the dispersed phase domains as micro reservoirs for enhanced release properties [1].

### 3. MATERIALS AND METHODS

The polymer blend of PVA-PEG were prepared with weight percentage of polyvinyl alcohol (60 wt.%) and polyethylene glycol (40 wt.%) by dissolving 1 gm of PVA and PEG in 20 ml of distilled water by using magnetic stirrer to mix the polymers for 1 hour to obtain more homogeneous solution. PVP was added with different concentrations: 10, 20 and 30 wt.%. The casting method was used to prepare the samples PVA-PEG-PVP blend. The samples prepared with thickness range 120-140  $\mu\text{m}$ . The structural, swelling and water absorption properties were studied. The pre-weighed dry samples were immersed in distilled water for 2 minutes at room temperature. The swollen polymer blend were then removed from distilled water and weighed after removing surface water. The swelling ratio was calculated as follows [16]:

$$\text{Swelling ratio} = (W_2 - W_1)/W_1, \quad (1)$$

where  $W_2$  is the weight of swelled sample, and  $W_1$  is the weight of dry sample.

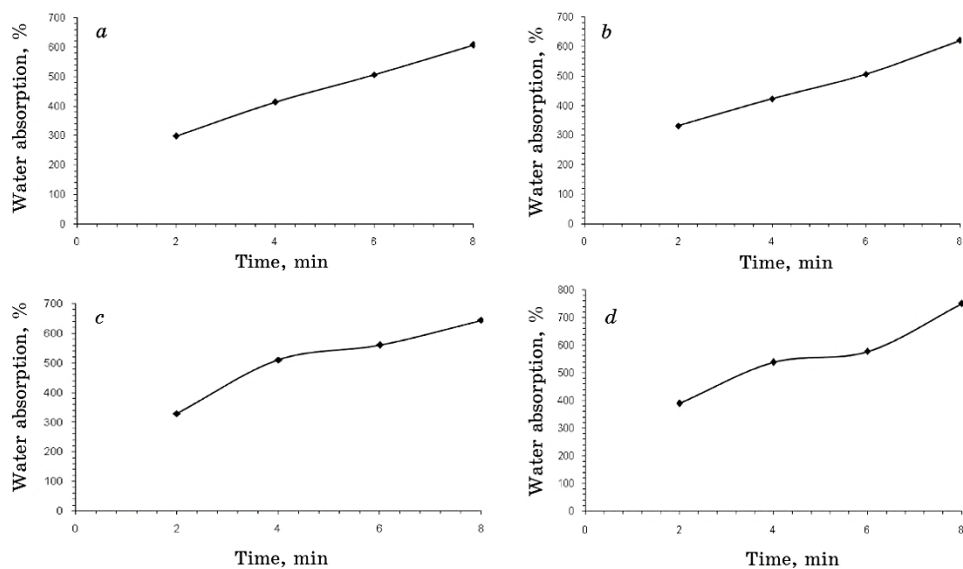
The pre-weighed dry samples were immersed in distilled water at room temperature and periodically weighed after soaking the surface water. The water absorption was calculated as follows [16]:

$$\text{Water absorbtion [\%]} = 100 \cdot (W_t - W_1)/W_1; \quad (2)$$

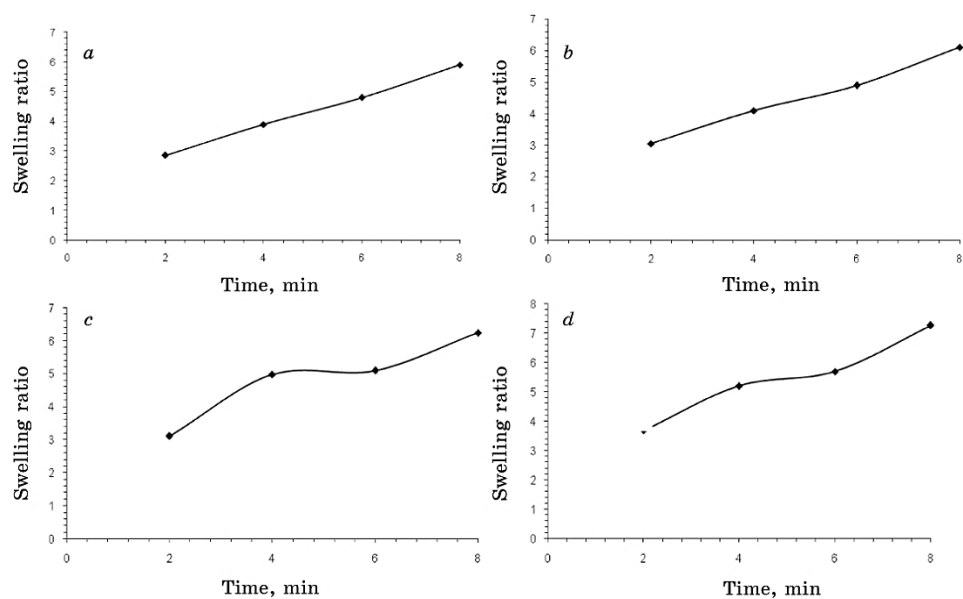
here,  $W_t$  is the weight of swelled sample at time  $t$ .

### 4. RESULTS AND DISCUSSION

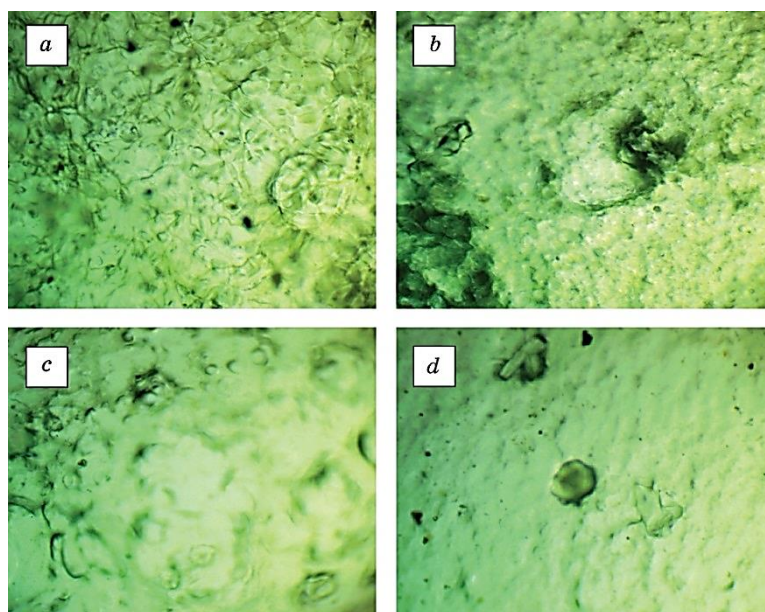
The water absorption and swelling dependency of the PVA-PEG blend on PVP amount is shown in Fig. 1 and Fig. 2.



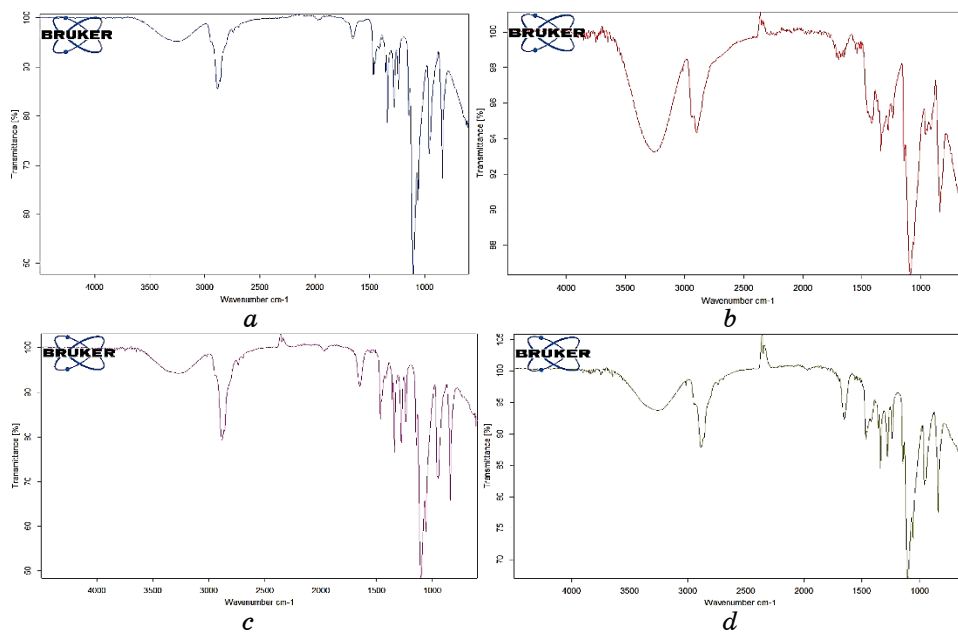
**Fig. 1.** Effect of PVP concentration on water absorption of PVA-PEG blend: *a)* for PVA-PEG blend; *b)* for 10 wt.% PVP; *c)* for 20 wt.% PVP; *d)* for 30 wt.% PVP.



**Fig. 2.** Effect of PVP concentration on swelling ratio of PVA-PEG blend: *a)* for PVA-PEG blend; *b)* for 10 wt.% PVP; *c)* for 20 wt.% PVP; *d)* for 30 wt.% PVP.



**Fig. 3.** Photomicrographs ( $\times 10$ ) for PVA-PEG-PVP blends: *a*) for PVA-PEG blend; *b*) for 10 wt.% PVP; *c*) for 20 wt.% PVP; *d*) for 30 wt.% PVP.



**Fig 4.** FT-IR spectra of PVA-PEG-PVP blends: *a*) for PVA-PEG blend; *b*) for 10 wt.% PVP; *c*) for 20 wt.% PVP; *d*) for 30 wt.% PVP.

The water absorption and swelling of PVA-PEG blend are considerably increased with the increase of PVP wt.%. This behaviour is attributed to the availability of more sites for crosslinking [17], as shown in Fig. 3.

FT-IR spectra of PVA-PEG-PVP blends for different concentrations of PVP are shown in Fig. 4. It shows broad bands at around  $3250\text{ cm}^{-1}$  for samples are observed due to OH groups in the polymers blends chain. The bands at around  $1280\text{ cm}^{-1}$  were attributed to the other bonds (C-O-C). The peaks at around  $1470\text{ cm}^{-1}$  were assigned to the C-O groups of polymers matrix. The band at around  $2890\text{ cm}^{-1}$  was attributed to the C-H groups. The strong band at  $1090\text{ cm}^{-1}$  for samples was attributed to the stretching mode of C-O group. The two strong bands observed at around  $1465\text{ cm}^{-1}$  and  $840\text{ cm}^{-1}$  are attributed to the bending and stretching modes of  $\text{CH}_2$  group, respectively [18, 19].

## 5. CONCLUSIONS

The water absorption of PVA-PEG blend increases with increase of the PVP concentration.

The swelling ratio of PVA-PEG blend increases with increase of the PVP concentration.

The FT-IR studies show that there are no interactions between PVA-PEG polymer blend and PVP.

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