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Chapter 25

METHOD OF CALCULATION OF EFFICIENCY DUST SEPARATION IN NEW DESIGNS DYNAMIC GAS WASHER

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ABSTRACT

In article the description of a new design dynamic gas washer, directed on increase of efficiency of clearing of gas emissions and decrease secondary carry –over of dust is given. Experimental researches which analysis has shown essential influence on process of separation of aerodynamics of a stream are carried out and has allowed to develop a new method of calculation of efficiency dust separation.

Keywords: dust, separation, new design, gas washer, analysis, stream, method of calculation.

SYMBOLS

η - efficiency dust separation;
t-Time of a relaxation, s;
ρ - density of a dust, kg / m^3;

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μ - dynamic viscosity $Pa \cdot s$;
m, n-parameters of distribution;
v-Speed of gas, m/s.

INTRODUCTION

Now in connection with intensive development chemical, oil refining and other industries all rises a problem of preservation of the environment more sharply.

Millions tons of harmful gaseous substances are thrown out annually in an atmosphere. Creation of high-power plants results in necessity of application of clearing constructions of high efficiency [1].

One of perspective directions of gas purification are separation the devices using effect of action of a field of centrifugal forces, allowing most full to realize advantages new power - intensive technologies.

Centrifugal devices are characterized by high efficiency, simplicity of a design and low metal intensive. Application of such equipment allows also essentially to intensify process mass transfer due to increase of speed of movement of phases [2].

As efficiency of separation is defined by requirements of concrete process, the big value gets correct calculation of speeds of movement of phases at which the high degree of clearing without occurrence of secondary ablation is achieved.

Without the decision of these, and also of some other questions, the further optimization processes of gas purification becomes difficult a problem.

1. DEVELOPMENT OF A NEW DESIGN DYNAMIC GAS WASHER

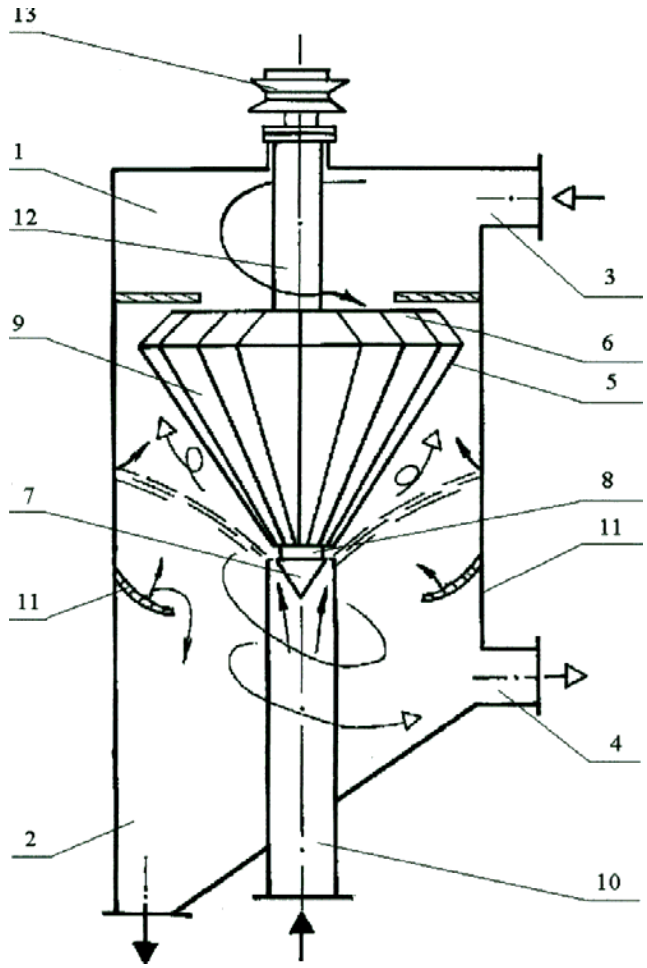
The new design highly effective dynamic gas washer, directed on decrease secondary ablation and a radial drain of particles [3] is developed.

The circuit dynamic gas washer is submitted in *figure 1*.

The gas stream containing mechanical or gaseous impurity, acts in the device on a tangential branch pipe 3. The liquid acts by means of an axial branch pipe 10. The bottom basis swirler 8 is placed at a level top cut an axial branch pipe 10, forming with it a backlash.

Due to this the liquid acts in the device as flat radial jets which, being reflected from the case 1, form a liquid veil that causes high-intensity contact of phases. Swirler contains blank off bottom 8 and the cylindrical top 6 bases connected with each other by means of unidirectional blades 9. Swirler it is fixed on a rotor 12 which is resulted in rotation by means of a belt drive 13. The centrifugal forces arising at rotation of a rotor 12, provide intensive crushing water gas a stream that results in updating a surface of contact of phases and an intensification of processes of an interphase exchange.

The basic advantage of the offered device is that rotation in a field of centrifugal forces, and also the offered organization of liquid jets, allow essentially to change a principle of work of the device and on the basis of it to improve the basic technical and economic parameters (a degree of clearing of gas, productivity, metal consumption).



The 1-case; 2-tap(removal) slime; 3,4-branch pipes of an input / conclusion of a gas stream; 5-conic swirler; 6-cylindrical swirler; 7-dissectior; 8-basis swirler; 9-blades; a 10-axial branch pipe 11-entrainment separator; a 13-pulley.

Figure 1. Dynamic gas washer.

2. An Experimental Research of Aerodynamics of a Stream

Research of aerodynamic laws of a biphase stream was carried out(spent) on the device in diameter of 0,25 m, height 0,6 m, on system air - water. During researches speed changed within the limits of 15-20 м/с. The charge of a liquid 0-3 m^3 / hour, the charge of gas 200-600 m^3 / hour.

Measurement of a field of speeds and static pressure was carried out with the help of a focused single-channel cylindrical probe in diameter of 4 mm. Techniques calibration a probe and realization of measurements were standard [4]. The chosen measurement technique does not allow to determine radial making speeds of the gas, however known experimental data specify that radial making speeds is scornfully small, in comparison with axial and tangential [5].

Results of measurements were represented in relative sizes.

$$\overline{\vartheta_t} = \frac{\vartheta_t}{\vartheta},$$

$$\overline{\vartheta}_Z = \frac{\vartheta_Z}{\vartheta},$$

$$\overline{\rho} = \frac{2\rho}{\rho \cdot \vartheta^2},$$

Where ϑ_z, ϑ_t - axial and tangential making speeds of gas, m/s;

p - Static pressure, Pa.

The analysis of experimental data has shown, that distinction in structure of the stream, caused by design features of the device, is shown only at a level swirler. For the device repeatability is characteristic Character of structures of speeds at return on a new coil of rotation, breakdown axiall symmetric, and also insignificant decrease of size tangential speed of a stream in process of his promotion.

3. Calculation of Efficiency Dust Separation

The carried out analytic review of methods of definition of efficiency dust separation in centrifugal devices has shown, that the new design procedure which is taking into account his design features is necessary for designing the developed device.

The equation for definition of general efficiency looks like:

$$\eta = \frac{\int_0^\infty F(t)\eta(t)dt}{\int_0^\infty F(t)dt},$$

Where t - time of a relaxation of the particle, determined under law Stoks:

$$t = \frac{d^2 \cdot \rho}{18\mu}$$

F (t) - differential function of distribution of particles of a dust on time of their relaxation;

η (t) - function of fractional efficiency dust separation.

Use t allows to take into account at realization of the disperse analysis of a dust form particles, their orientation, and also forces of interaction of particles.

Function of distribution of particles is described by equation Rosin-Rammler, and, entering concept of boundary time of a relaxation t_{lim} and relative time of a relaxation $\bar{t}$, we shall receive:

$$\bar{t} = t / t_{\lim},$$

$$F(\bar{t}) = p \cdot n \cdot \bar{t}^{n-1} \cdot \exp(-p \cdot \bar{t}^{n}),$$

$$p = m \cdot t_{\lim}^{n},$$

Where a p-complex which is taking into account dispersiveness and properties of a caught dust (parameters m and n).

The equation for definition of general efficiency will look like:

$$\eta = \exp(-p) + p \cdot n \cdot \int_0^1 \bar{t}^{n-1} \cdot \exp(-p \cdot \bar{t}^{n}) \cdot \eta(\bar{t}) d\bar{t}$$

Function η ($\bar{t}$) is described by the equation of a kind:

$$\eta(\bar{t}) = \bar{t}^{a} \cdot \exp[b \cdot (1-\bar{t})]$$

Parameters a=2,47; b=3,08 are determined as a result of experimental researches then function of general efficiency will become:

$$\eta = \exp(-p) + p \cdot n \int_0^1 \bar{t}^{n-1,15} \cdot \exp[(-p \cdot \bar{t}^{n}) \cdot 3{,}08 \cdot (1-\bar{t})] d\bar{t}$$

The received equation allows to define efficiency of gas purification depending on geometrical features of the device and his aerohydrodynamical characteristics.

CONCLUSIONS

1. the new design highly effective dynamic gas washer, directed on improvement of the basic technical and economic parameters (a degree of clearing of gas, productivity, metal consumption) Is developed.

2. the method of calculation of efficiency of gas purification with use of distribution Rosin-Rammler which takes into account influence on process of separation of aerohydrodynamical characteristics of a stream is offered.

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Chapter 26

THE BASES OF THE TECHNOLOGICAL MAINTENANCE OF POLYMERIC IMPLANTS' BIOCOMPATIBILITY

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ABSTRACT

The new complex approach to the problem of implants' biocompatibility is proposed. The oriented phototechnology is developed for the modification of the silicon intraocular lens that enables to increase the biocompatibility.

Keywords: polymeric implants, biocompatibility, silicon intraocular lens, phototechnology, technological adaptation, IR- spectroscopy, UV-spectroscopy, chromatography.

The wide use of artificial materials for manufacturing of the medical implants determined that the study of laws of their interaction with biological structures is necessary to be provided [1,2].

The accumulation of the experimental data, the expansion of methodical base for research of the biocompatibility of "alive" and "lifeless" substance and the search of the most informative physical and chemical characteristics of polymers have observed during several decades. Finally, it assumes the development of the special technologies for reception of polymeric products for medical purposes.

The retrospective analysis of the problem of bearableness of polymeric implants has shown that positions of the theory of biotechnical systems were not applied in the development the approaches to its decision. That reflected on treatment of the results of toxicological techniques to research from the point of final result ("a black box").

The absence of the complex techniques to research of the interaction of elements of the system "implants - biological environment" on border of division of phases and ignoring of some fundamental laws established within the limits of the physical chemistry of polymers are marked.

By virtue of the specified features there was a certain break between theoretical consideration of questions of the polymeric implants' bearableness and the experimental data complicated the further promotion in the decision of problems of reception the biocompatible polymeric products of various functions and on the basis of the directed technologies.

Thus use of the system positions with reference to an artificial crystalline lens (intraocular lens (IOL)) enabled to determine that despite of the extensiveness and duration of researches of bearableness of lenses, these researchers had the isolated character. Thus, insufficient attention was paid to the research of own physical and chemical characteristics of IOL and their transformation during the manufacturing and at contact with biological environments. Apparently, such unilateral approach has led to what even at full passage tested under special program IOL with a positive estimation « "toxic- syndrome" has not been eliminated. However these results were considered only as the certificate insufficient information both reliability of the developed tests and absence of knowledge etiopathogenesis complications.

The correlation between thermodynamic balance of superficial layer with the contiguous volumetric phases (which are defined by the general conditions of heterogeneous balance) was assumed as a basis of the proposed approach to the problem of the increase of polymeric implants' biocompatibility.

This approach enabled to consider the power and electric characteristics of surface as unified display of the processes proceeding in a superficial layer of a polymeric material in contact with the biological substance. The theoretical positions describing behavior of the superficial layer of polymer enabled to prove the necessity of inclusion in standard technological process of polymeric implant (IOL) production at the special stage of "technological adaptation".

The "technological adaptation of a polymeric implant" is a number of technological operations which introduction in a standard technological process enables to create already at production phase such a physical and chemical structure of a superficial layer of polymer that will be adequate to biological structures.

In other words, already during the manufacturing process it is possible to lower considerably the efforts of the body to bring the system "implant - biological environment" in stability.

It should be noted that the additional technological stage is not limited to carrying out of various kinds of modifications (physical, chemical, etc.), but also includes the creation of focused supramolecular structures of a superficial layer through maintaining the optimum conditions for its relaxation.

The methodical complex included physical, chemical and toxicological methods of the research. The fundamental methods (IR-, UV-spectroscopy, chromatography, physicomechanical tests etc.) and the original techniques, enable to reach optimization of the technological modes of silicon IOL adaptation. The complex biotechnical technique was formed stage by stage.

At the first stage of researches on the basis of photometric a method (copyright certificate SU 1529112 A1) the tool technique of the hygienic control silicon for medical purposes has been developed. The research of the definition of absorption in a range of waves' length (350-

190 nanometers) was carried out. The characteristic strip of absorption of microimpurity was revealed.

A degree of toxicity of the microimpurity contained in extracts, and their influence on the energy metabolism of cells judged by results of: estimations of extracts' toxicity from polymeric materials by studying of the activity of bull sexual cells suspension, caused own mobility; the test for culture fibroblasts a cornea of the rabbit. The quantitative communication between the optical density of an extract on the established length of wave and the results of the toxicological test "alive cells" was estimated. The quantitative assessment of correlation (r = - 0,673) was used as a quantitative estimation of the narrowness of communication of both tests. Based on the statistical processing or empirical results, the confidence bounds were defined for the general correlation factor $-0{,}788<r<-0{,}520$. The empirical equation of theoretical line of regression is $y=100e^{-4{,}221x}$.

The second stage of researches was directed on the elimination of such lacks of silicon IOL as water repellency and discrepancy of the spectral characteristics of material to spectrum transmission of a natural crystalline lens to UV-areas. The phototechnology has been developed for that purpose.

As the result of silicon lens modification the chemical compound of the superficial layer has changed in particular the hydrophilous groups are formed; not reacted trailer groups are finished; the absorption in UV-area of a spectrum increase.

However the modification of superficial characteristics of silicone appeared insufficient for the adequate coupling of elements of the biotechnical system "implant - biological environment". It is caused by the fact that the structures of IOL surface are non-equilibrium.

The analysis of behavior of the processed silicon material surface in contact with biological environment enabled to determine the stages of the mechanism of its relaxation which final result is formation of the focused secondary structure. Apparently, it will define reaction of an eye to an implant.

The established laws contributed to develop the technique for production of silicon intraocular lenses of the higher biocompatibility.

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Chapter 27

STIMULI-RESPONSIVE DRUG DELIVERY SYSTEM

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ABSTRACT

The interpenetrated network systems (IPN) or hydrogels which are *biodegradable and also stimuli-responsive* are special materials explored lately and a subject of great interest in the last years.

This paper deals with synthesis, characterization and drug release behavior of a new biodegradable stimuli-sensitive hydrogel containing alginic acid (ALG) and N-isopropylacryl amide (NIPAM).

The properties and morphology of the mixed alginic acid (ALG) /N-isopropylacryl amide (NIPAM) hydrogel were investigated through swelling kinetic studies performed at different temperatures and pHs, rheology and environmental scanning electron microscopy (ESEM). The controlled release of ketoprofen from this hydrogel was also followed. The studies performed allowed us to ascertain the sol-gel transition temperature and the gel point for the investigated hydrogel, to observe the morpgology of the gel as the water content changes and also thermal behavior.

Keywords: hydrogel, polysaccharide, biodegradable, stimuli-responsive

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INTRODUCTION

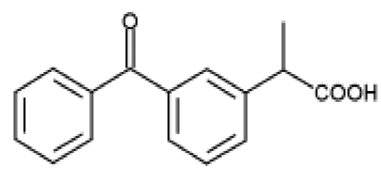
The development of new polymeric systems, which are *biodegradable and also stimuli-responsive* is a subject of great interest in the last years. The hydrogels capable to undergo drastic volume changes (volume phase transition) in response to small variations in the external conditions, such as temperature, pH, solvent, ionic concentration, electric field or light irradiation were named „stimuli-responsive“ or „intelligent“ gels, having a great potential for applications in high-performance areas such as biosensors, bioseparators, bioreactors, in tissue engineering, or in controlled drug delivery systems through responding to environmental stimuli by swelling / deswelling.

In an attempt to obtain biodegradable materials with sensitivity to external stimuli, like pH and/or temperature, biopolymers from renewably resources were associated with thermo-sensitive macromolecules. [1,2]

Various stimuli-responsive hydrogels have been developed for drug delivery, based especially on poly(*N*-isopropylacrylamide) (PNIPAM), which is one of the most widely studied thermosensitive polymers, exhibiting a volume phase transition at a lower critical solution temperature (LCST) in water of around 32^0C [3], close to physiological temperature.

Alginate, a natural polysaccharide derived from brown seaweeds composed of D-mannuronic acid and D-guluronic acid is one of the biodegradable polymers used to obtain pH-sensitive hydrogels Alginate hydrogels are pH-sensitive and biocompatible, with a relatively low cost. [4]

Ketoprofenul is a derivate of the propionic acid with the following structure



Ketoprofen is a white crystalline powder insoluble in water but soluble in acetone, ethanol methylene chloride, chloroform, ether and benzene. Ketoprofen is an anti-inflammatory, analgezic and antipiretic drug efficient in the treatment of the rheumatoid arthritis and osteoarthritis, spondylitis, as well as soft tissue injuries, such as tendinitis and orthopedic pain surgery, inflammatory desease-gout, to relieve minor aches and pain from headaches, toothaches, the common cold, muscle aches, and backaches, Reiter's syndrome, dysmenorrhoea, metastatic bone pain, pyrexia and to reduce fever. It works by stopping the body's production of a substance that causes pain, fever, and inflammation.[5] Its anti-inflammatory action is 20 times higher than that of ibuprofen, of 80 times higher than that of phenylbutazone and of 160 times higher than that of aspirin. [6-9]

Because is water-insoluble several techniques have been tested to improve the solubility, as solid dispersion, complexation, etc. Frequent administration is necessary because of its rapid elimination from organism (half-life time of 2 – 2.5 hours). The high quantities of ketoprofen in stomach determine gastric troubles as ulcers, bleeding, or holes in the stomach or intestine. Controlled release of this drug should permit a less frequent administration and reduction of the gastrointestinal pains. It is known the use of the microspheres of ethylcellulose as matrices for controlled release or coating with chitosan to increase accesibility by bioadehsion.[10]

EXPERIMENTAL

Alginic acid (ALG) from brown algae (Fluka), Mw 48 000 - 186 000, $\eta_{red}^{25^oC} = 2.41\ ml \cdot g^{-1}$, c = 0.2 g/dL; N-isopropylacryl amide (Aldrich) 97% (NIPAM); crosslinking agent: N,N'-methylenebisacrylamide (Fluka) (bis). The hydrogel with 75 % NIPAM / 25% ALG composition was obtained by simultaneously polymerization/crosslinking reaction using 4 wt% crosslinking agent amount in respect with NIPAM. It was purified by five repeated washings with twice-distilled water.

Swelling kinetic studies – performed by weight measurements, at different temperatures and pHs. Swelling ratio (SR) determined according to the equation:

$$SR(\%) = \frac{W_S - W_D}{W_D} \times 100 \quad (1)$$

Temperature range was 20 – 40 ^{o}C while pH values studied were: 2.2, 5 and 7.2.

Thermo-gravimetry analysis (TG/DTG) - performed by a thermo-gravimetric analyser Mettler STARe SW 8.10; samples weight ~3 mg, heat rate 10 ^{o}C/min.

Rheology measurements – performed with a Bohlin rheometer C-VOR, equipped with a Pelltier stage for temperature variation; frequency range 0.01-1 Hz, constant strain 10%.

ESEM studies – performed with a FEI Quanta 600 FEG Environmental Scanning Electron Microscope; measurements at different degrees of relative humidity (RH) and magnifications.

Drug release studies - Loading of the Ketoprofen in 75% NIPAM/25%ALG hydrogel matrix was done by swelling in ethanol solution followed by freeze-drying.

The release profile of Ketoprofen from 75% NIPAM/25%ALG hydrogel matrix having various degrees of swelling at the same drug concentration was determined based on UV-VIS spectroscopy measurements. With this aim an UV-VIS spectrofotometer HP 8540A type was used. The calibration was done with solutions of ketoprofen in ethanol of concentrations varying 10^{-5} to 10^{-2} g/L. The characteristic wavelength of ketoprofen is 254 nm. Prevealing of the samples was made at constant time intervals.

This paper deals with synthesis, characterization and drug release behavior of a new biodegradable stimuli-sensitive hydrogel containing alginic acid (ALG) and N-isopropylacryl amide (NIPAM).

RESULTS AND DISCUSSION

Polymerization/chemical crosslinkig reaction of NIPAM in presence of alginic acid and N,N'-methylene bisacrylamide leads to a semi-transparent hydrogel stable in water, and acidic solutions a very long time keeping its shape and characteristics. It is hydrophilic absorbing from atmosphere approximately 10 wt% of water, as it resulted from thermogravimetric analysis and repeated weighing of sample kept in room conditions. It is also thermally stable as it appears from DTG curves presented in figure 1.

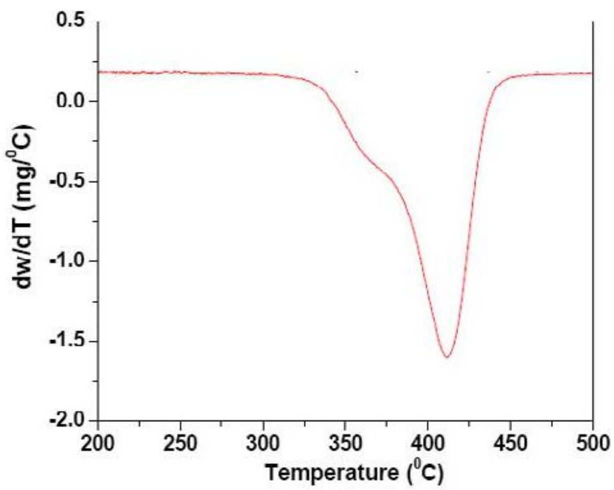


Figure 1. DTG curve of the 75/25 NIPAM/ALG dry hydrogel.

It decomposes in nitrogen atmosphere starting with 290 ^oC reaches a maximum of decomposition at 409 ^oC, the final weight loss in this main decomposition process being of 86 wt% - table 1.

Table 1. Thermogravimetric data for 75/25 NIPAM/ALG dried hydrogel

Sample	Δw (%)	Characteristic Temperatures (^{o}C)		
		Onset temperature of degradation (T_i)	Temperature corresponding to maximum weight loss (T_m)	Final temperature (T_f)
75 %NIPAM/25% ALG	86	290	408	477

The swelling behavior of the sample in response to temperature and pH of the external media is manifested by the decrease of the swelling capacity with increasing temperature (table 2). It was observed a similar behavior at pH 2.2 and 7.2, with a slightly increased capacity of swelling at acid pH – table 3.

Table 2. Maximum swelling degree values in ethanol for the 75%NIPAM / 25 %ALG hydrogel at different temperatures

Temperature (^{0}C)	Q_{max} (wt %)
20^{0}C	3734
30^{0}C	2679
33^{0}C	1817
35^{0}C	844
40^{0}C	485

Table 3. Maximum swelling degree values in ethanol for the 75%NIPAM / 25 %ALG hydrogel at different pH values

pH	Q_{max} (wt %)
2.2	486
5	911
7.2	339

By analysing the graphical representation of the maximum swelling degree versus temperature -figure 2 – it can be seen a sudden variation which can be associated with a transition temperature.

For accurate determination of the transition temperature the curve was fitted by a Boltzmann function (using Origin 6.1 program) given by equation:

$$y = \frac{A_1 - A_2}{1 + e^{\frac{(x - x_0)}{dx}}} + A_2$$

where:

A_1- minimum value of the function

A_2 – maximum value of the function

x_0 - value on the x axis corresponding to the inflexion of the curve, equivalent to the transition temperature;

dx - domain in which this value is found

The reduced chi-squared, for all the fitted curves was of $\chi^2 \leq 0.1$, therefore the use of this function is a good approach.

A transition at 31.9 ^oC was found which can be associated with gel point of the system.

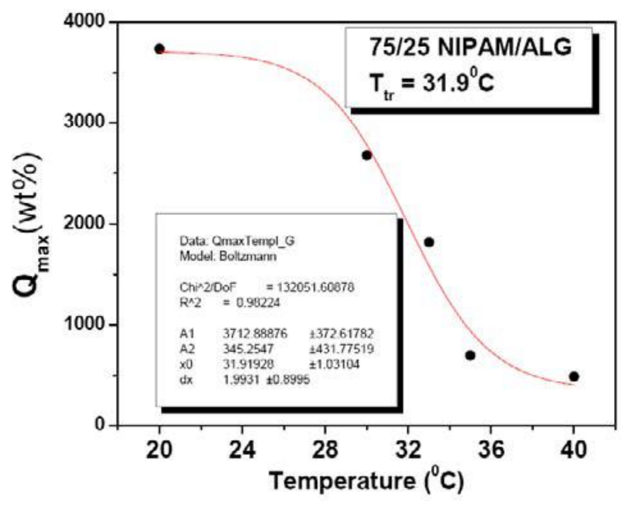


Figure 2. Qmax versus temperature for 75%NIPAM / 25 %ALG hydrogel.

Rheological behavior is influenced by temperature changes proofing the thermo-responsive properties of the 75%NIPAM / 25 %ALG hydrogel.

It can easily remarked that the gel point shifted toward lower frequency with increasing temperature – figure 3.

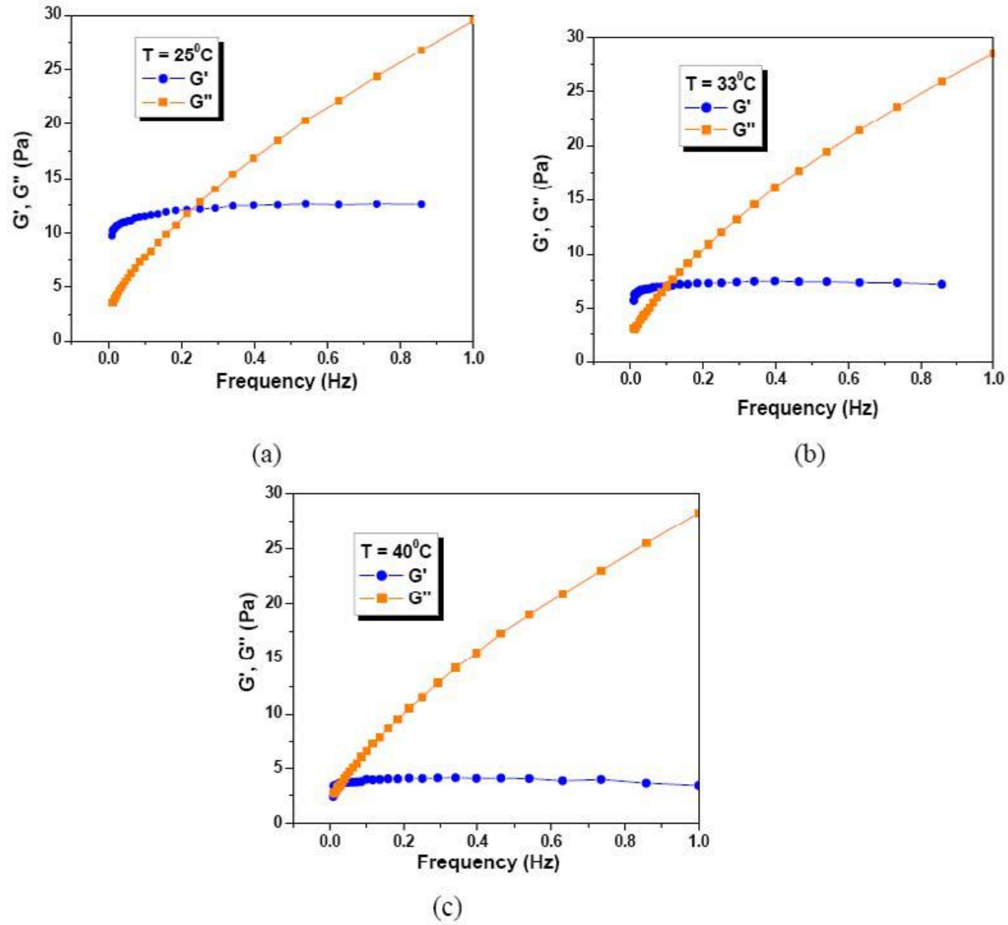
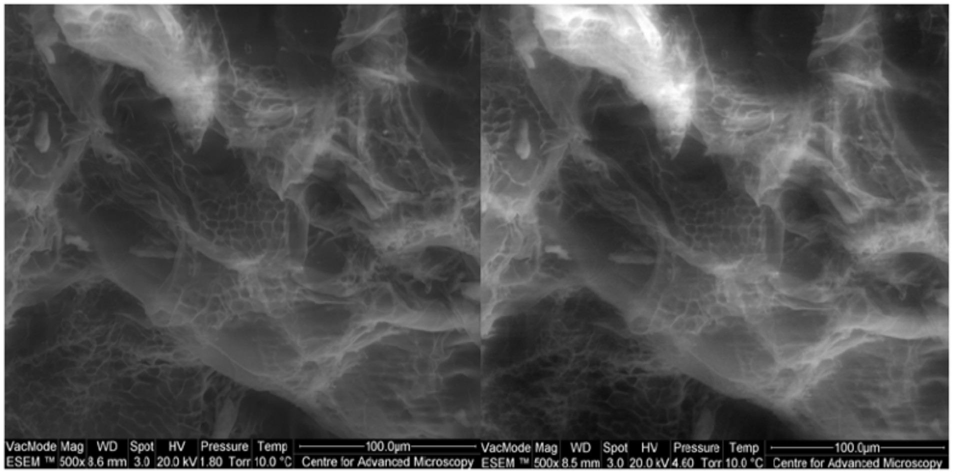


Figure 3. G' and G" of the 75%NIPAM / 25 %ALG hydrogel versus frequence at different temperatures.

ESEM study reveals a porous morphology with a honeycomb-like structure – figure 4.

Morphological aspect and cavities dimensions (increase) modify as the water content changes.

The release profile of the ketoprofen from 75%NIPAM / 25 %ALG hydrogel matrix is different depending on solvent content in the gel, the higher solvent content the lower is the quqntity of the released drug which is ~ 100% from loaded quantity for un-swollen matrix that means physically mixing of matrix with drug and decreases at about 60 % from loaded quantity when the matrix was swollen at maximum SR = 3300%. The matrix swollen in drug solution up to a SR = = 1650 % show and intermediary behaviour between physically loading and the case when maximum SR was used. – figure 5.



a b

Figure 4. ESEM micrographs of the 75NIPAM/25 ALG hydrogel at RH 20% (a) and 50% (b).

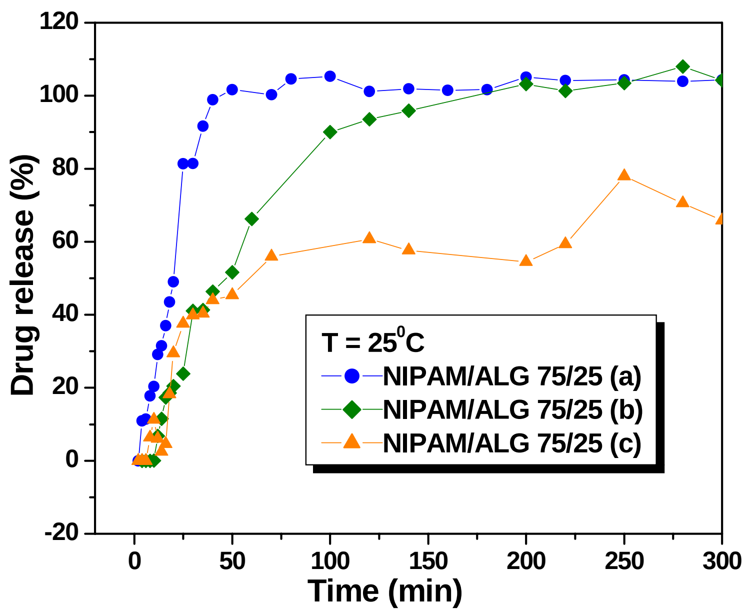


Figure 5. Drug release profile of ketoprofen at 25^0C from 75%NIPAM/25% ALG hydrogel with different swelling ratios in ethanol a) unswollen; b) SR = 1650 %; c) SR = 3300 %.

A difference appear also in the release rate of the three kinds of matrix loading with ketoprofen – figure 6. The higher is SR of hydrogel matrix the slower release rate of the drug from the matrix

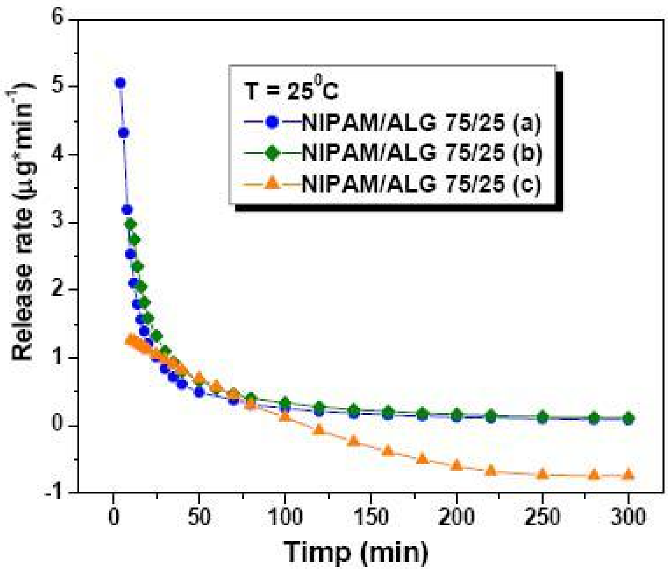


Figure 6. Drug release rate of ketoprofen at 25^{0}C from 75%NIPAM/25% ALG hydrogel with different swelling ratios in ethanol a) unswollen; b) SR = 1650 %; c) SR = 3300 %.

CONCLUSIONS

The swelling and rheology studies performed allowed us to ascertain that the 75 wt% NIPAM/25% ALG semi-interpenetrating network (hydrogel) obtained possess thermo- and pH-responsive properties. Morphological examination by ESEM microscopy showed a porous morphology which modifies when the water content changes. The drug release profiles depend on solvent quantity used for drug loading.

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