The effect of ultrasound on the polymerization of methacrylic esters compositions with polyvinylpyrrolidone and mineral fillers

Volodymyr Skorokhoda, Galyna Dudok, Iryna Dziaman, Taras Skorokhoda

Department of Chemical Technology and Plastics Processing, Lviv Polytechnic National University, Ukraine, Lviv, 12 Bandery str. E-mail: vskorohoda@yahoo.com

Abstract - the impact of ultrasound on the laws of the polymerization of methacrylic ester compositions with polyvinylpyrrolidone and mineral fillers has been investigated. The influence of ultrasound, the nature and amount of inorganic filler, the intensity of ultrasound on the rate of polymerization, the composition of the copolymers and the porosity of the composites has been established. It is confirmed that ultrasound significantly intensifies the polymerization and actively influences the formation of the composition of the copolymers.

Keywords - polyvinylpyrrolidone, ultrasound, mineral fillers, porous composites, filler, hydroxyapatite, osteoplastic materials.

Introduction

High adaptability to existing technologies, flexibility and efficiency, the possibility of using ultrasound (US) in a wide frequency range allows the use of ultrasonic technologies. Both basic and auxiliary methods that allow to intensify technological processes and significantly improve the quality characteristics of the received materials.

The purpose of the work is to investigate the effect of ultrasound on the polymerization of glycol methacrylate esters with polyvinylpyrrolidone (PVP) in the presence of mineral fillers, to determine the effect of the amount and nature of inorganic filler, PVP content and ultrasound intensity on the polymerization rate, composition of copolymers and porosity of composites.

Results and discussion

Ultrasound was used to create active polymerization centers in viscous monomer-polymer compositions and to disperse the filler in the polymer composition and improve the uniformity of its distribution. For this purpose, the ultrasonic device "Wave" was used (the frequency of mechanical vibrations - 22 ± 1.65 kHz, the power control interval - 0-400 VA). Composites were filled with mineral fillers of various nature (hydroxyapatite, volostanit, montmorillonite, tricalcium phosphate).

It has been established that the compositions of (meth)acrylic esters of glycols with PVP under the action of ultrasound polymerize at high speed in heterogeneous conditions even without using traditional polymerization initiators at low temperatures. Homogeneous compositions polymerize much more slowly and subject to the presence of radical polymerization initiators in the reaction mixture.

The active influence of the nature and amount of the filler on the grafting parameters, the composition of copolymers and the properties of composites based on them has been established. Mineral fillers create a heterogeneous environment in the compositions, as a result of which, under the action of ultrasound, polymerization occurs very quickly with simultaneous foaming of the composition, which provides additional technological advantages in creating a technology for producing porous composites.

Depending on the nature of the mineral filler, the reaction of polymerization of compositions under the action of ultrasound, can occur both by the radical and ionic mechanisms. The participation of PVP in graft and block copolymerization reactions was confirmed by infrared spectroscopic studies. The main results of kinetic studies are given in the Table 1.

Table 1

The effect of ultrasound on the rate of polymerization (*T = 298 K, 120 VA*)

№	The composition of the polymer-monomer materials, mass.p			$V_p \cdot 10^2$	Maximum monomer conversion ,%	Time to reach to maximum conversion, s
	HEMA	PVP	filler			
1	100	0	0	0	–	–
2	70	30	0	2,2	90	190
3	70	30	70 HA	10,4/0,42	94	50/7500
4	70	30	100 HA	12,1	96	50
5	70	30	150 HA	17,5	97	45
6	70	30	70 WL	11,8	96	45
7	70	30	70 MMT	16,6	95	35

HA – hydroxyapatite, WL - wollastonite, MMT – montmorillonite.
- denominator without using ultrasound at 328 K.

The composites obtained under the action of ultrasound have a pronounced porous structure, which is confirmed by photographs taken using transmission electron microscopy. Under the action of ultrasound, the porous structure of the composites is formed, even without the use of special blowing agents. The basic properties of porous composites (total porosity, pore diameter, conditional density, compressive strength) are investigated in dependance on the composition of the original compositions, the nature and the amount of filler. With the same filler content in the case of using montmorillonite, the obtained composites are marked by the smallest average pore size. Composites with wollastonite have the largest pore diameter and low mechanical properties.

Conclusion

The expediency of using ultrasound for the formation of composites based on methacrylic ethers with PVP, filled with fine mineral fillers, has been confirmed. The use of ultrasound allows polymerization at room temperature and to achieve a high degree of monomer conversion to the polymer in a short time. This will significantly intensify the process of obtaining porous composites and increase its performance.

References

[1] Skorokhoda V., Semenyuk N., Dziaman I. and Suberlyak O. (2016). Mineral filled porous composites based on PVP copolymers with bactericidal properties. Chem. & Chem. Technol., 11(2),171.

[2] Semenyuk N., Dzyaman I., Skorokhoda V. (2016). Tekhnolohichni osoblyvosti oderzhannya porystykh polimernykh kompozytiv na osnovi kopolimeriv polivinilpirolidonu. Naukovyy visnyk NLTU Ukrayiny, 26.4, 290-295.