Investigation of the influence of the composition on mechanical properties poly(glycolide-DL-lactide)

A S Baikin, M A Sevostyanov, E O Nasakina, K V Sergienko, M A Kaplan, S V Konushkin, A A Kolmakova, A D Yakubov, A G Kolmakov

A.A.Baikov Institute of Metallurgy and Materials Science, Russian Academy of Sciences

Email: baikinas@mail.ru

Abstract. In this paper we describe the creation of films from poly (glycolide-DL-lactide). Studied the mechanical properties of developed polymer films of poly (glycolide-DL-lactide). The effect of the molecular weight of poly (glycolide-DL-lactide) on the mechanical properties of the resulting polymer films is shown. The dependence of the mechanical properties of poly (glycolide-DL-lactide) films on the polymer concentration in chloroform was studied. The possibility of creating biodegradable films with specified mechanical properties is shown.

1. Introduction

At the end of the 20th century, a special device was invented and put into practice, called a "cava filter" (a medical device implanted in the lumen of the inferior vena cava to catch clots carried by the bloodstream). Currently, in medical practice, operations involving the use of a "cava filter" are widespread, and active development of new products continues, since in addition to the merits they all also have significant drawbacks. Together with the establishment of "cava-filters", drugs are treated. Most drugs used for systemic prevention can cause bleeding. Therefore, now work is underway to create "cava-filters" with a superficial drug layer that provides a local effect of the drug. However, there is a rapid leaching of the drug agent from the surface of the "cava filter". At the same time, the required duration of exposure to the drug is not achieved and its desired concentration in the blood is not maintained. This problem can be solved by administering the drug to the biopolymer layer to prevent rapid elution and to provide a controlled release of the drug into the bloodstream. [1-4]

When choosing a material for the development of controlled drug delivery systems, the following considerations are guided: the material must be chemically inert, do not contain leachable impurities, be easily synthesized, and in the case of hydrolysis (or resorption), do not form toxic compounds. They are silicone, polyurethanes, polyethylene, polyethylene vinyl acetate. Long-used materials are being used in medicine, new polymers are being developed that meet the requirements that are imposed on the rate of disintegration and the physical characteristics of delivery systems. The need to use biodegradable materials for this purpose led to the active development of biodegradable polymers of synthetic and natural origin, among which the greatest development was obtained by polyesters: polylactides, polylactide glycolides, polyethylene glycol, polyanhydrides, polyorthoesters, polysaccharides (starch, dextran, chitosan). [5-8]

In this paper, films based on poly (glycolide-lactide) of different molecular weights are considered. Polyglycolide is the simplest polyester in which, due to the close arrangement of ester groups,
intermolecular interactions are strongly pronounced, has a high degree of crystallinity, a high melting point (~ 300 °C), and extreme hydrolytic instability. Polylactide is an aliphatic polyester whose monomer is lactic acid. It is biodegradable, biocompatible and thermoplastic. Using polylactide / polyglycolide copolymers, the rate of bioresorption varies depending on the type of polymer and its molecular weight [9].

The physico-chemical properties of these polymers are determined by the molar ratio and the sequential arrangement of lactic and glycolic acids. Copolymers can be obtained with different molecular weights and the structure of macromolecules, which makes it possible to vary the degree of interaction between macromolecules. Based on lactide and glycolide, it is possible to obtain a whole family of copolyesters whose properties will differ within a certain range. The more the ratio between lactide and glycolide, the more hydrophobic the substance will be and the more soluble it will be. The decomposition times are shorter for polymers with a lower molecular weight, greater hydrophilicity and a larger content of the amorphous portion, as well as a higher content of glycolide in the copolymers. [10]

Poly (glycolide-D, L-lactide) is soluble in most solvents, including chlorinated solvents, tetrahydrofuran, acetone, ethyl acetate. In the work, chloroform was chosen as the solvent. [11]

2. Materials and methods
To create the films, we prepared samples of polymers of mass 2; 6 and 10 g (± 0.01 g). Chloroform, 200 ml in volume, was placed in a 500 ml flask and heated to 80 °C with a magnetic stirrer. Further, the polymer samples weighed were dissolved to a homogeneous state in chloroform at 80 °C for 1 hour with constant stirring by means of an electronic overhead stirrer.

At the end of dissolution of the polymer, the volume of the solution was adjusted with chloroform to 200 ml. The resulting solution was aged for 5 minutes at 80 °C and spread over glass pallets.

Drying was carried out for 2 days in air at 37 °C in a thermostat.

The obtained samples were assigned ciphers used for independent research in the future (Table 1):

| Code | Polymer                          | Molecular weight, kDa | Concentration, g per 100 ml of chloroform |
|------|----------------------------------|-----------------------|------------------------------------------|
| 1.1  | Poly (glycolide-DL-lactide)      | 45                    | 1                                        |
| 1.2  | Poly (glycolide-DL-lactide)      | 45                    | 3                                        |
| 1.3  | Poly (glycolide-DL-lactide)      | 45                    | 5                                        |
| 2.1  | Poly (glycolide-DL-lactide)      | 90                    | 1                                        |
| 2.2  | Poly (glycolide-DL-lactide)      | 90                    | 3                                        |
| 2.3  | Poly (glycolide-DL-lactide)      | 90                    | 5                                        |
| 3.1  | Poly (glycolide-DL-lactide)      | 180                   | 1                                        |
| 3.2  | Poly (glycolide-DL-lactide)      | 180                   | 3                                        |
| 3.3  | Poly (glycolide-DL-lactide)      | 180                   | 5                                        |

Tensile strength studies of polymeric films from polylactide were carried out on a universal test machine INSTRON 3382 at a loading rate of 10 mm / min. Samples of polymer films for testing were made in accordance with GOST 14236-81, in the form of a double blade. The sample was fixed in the
grippers of the testing machine, which was tightened evenly to ensure that the sample did not slip during the test. Tests of polymer films with determination of the relative elongation, yield strength and tensile strength were carried out in accordance with GOST 14236-81. The processing of the test results in determining the characteristics of mechanical properties was carried out using the software INSTRON Bluehill 2.0. The measurement error of the test machine is less than 1%. Five samples were tested for one experimental point. The values of yield strength \( \sigma_y \), tensile strength \( \sigma_t \) and deformation \( \delta \) were determined.

3. Results and discussion

Table 2 presents the averaged results of mechanical tests of polymer films for each composition based on polyglycolide-lactide (PGLA) with different molecular weights from different dissolution concentrations in chloroform.

From the results obtained, graphs of the dependence were plotted, along which it is possible to trace the tendency of the change in mechanical characteristics (Figures 1-3).

As can be seen from the diagrams shown in Figures 1-3, the thickness of the poly (glycolide-lactide) films, the mechanical properties of the films (strength, ductility) depend on the conditions for their production. By varying the molecular weight and concentration of the polymer in the chloroform solution, films with the desired characteristics can be obtained.

Increasing the concentration of the polymer in the solution promotes thickening of the polymer layer, thereby increasing plasticity, but decreasing the strength of the polymer film.

Table 2. Mechanical properties of polymer films.

| Code | Polymer and concentration | Deformation, % | Yield strength, MPa | Ultimate Strength, MPa | Thickness, \( \mu \text{m} \) |
|------|--------------------------|----------------|---------------------|------------------------|---------------------|
| 1.1  | PGLA 45kDa 1x100         | 139,52         | 3,96                | 5,51                   | 66                  |
| 1.2  | PGLA 45kDa 3x100         | 303,48         | 1,88                | 3,63                   | 155                 |
| 1.3  | PGLA 45kDa 5x100         | 447,17         | 0,37                | 1,82                   | 224                 |
| 2.1  | PGLA 90kDa 1x100         | 262,21         | 2,42                | 5,17                   | 63                  |
| 2.2  | PGLA 90kDa 3x100         | 369,34         | 0,47                | 4,18                   | 148                 |
| 2.3  | PGLA 90kDa 5x100         | 432,73         | 0,27                | 2,35                   | 258                 |
| 3.1  | PGLA 180kDa 1x100        | 198,32         | 5,59                | 7,62                   | 32                  |
| 3.2  | PGLA 180kDa 3x100        | 376,73         | 0,48                | 4,47                   | 154                 |
| 3.3  | PGLA 180kDa 5x100        | 554,91         | 0,27                | 1,83                   | 252                 |
Figure 1. Diagram of deformation depending on the concentration of the solution for PGLA

Figure 2. Diagram of the dependence of tensile strength on the concentration of solution for PGLA
Figure 3. The diagram of the dependence of the thickness of polymer films on the concentration of solution for PGLA

4. Conclusions
Studies of the mechanical properties of the developed polymer films of poly (glycolide-lactide) were carried out. The dependences of the mechanical properties of the resulting polymer films on the molecular weight of poly (glycolide-lactide) and on its concentration in the chloroform solution are revealed. The possibility of creating biodegradable films with specified mechanical properties is shown.

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