Improving the Properties of Polyurethane Foam by Adding Urea Powder

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Abstract. Samples of pure polyurethane (polyol + isocyanate) were prepared as well as other samples by adding urea powder, and when adding urea powder, the flexibility and cohesion of polyurethane improved, as well as its thermal conductivity decreased and its density increased, as well as flame and fire resistance. The best ratio was 5g of urea for each 12cm³ polyurethane.

Key words: Polyurethanes, Urea, Heat resistance

1. Introduction

Polyurethane has many uses in building insulators, roofs, refrigeration devices, cars and countless applications because of its good advantages in insulation, moisture resistance and ease of application [1-3]. Polyurethanes are produced by reacting diisocyanates with polyols. A polyol is an organic compound containing multiple hydroxyl groups. The term “polyol” can have slightly different meanings depending on whether it is being used in the field of food science or that of polymer chemistry. Polyols containing two, three and four hydroxyl groups are a diol, triol, tetrol and so on. Isocyanate is the functional group with the formula R−N=C=O. Organic compounds that contain an isocyanate group are referred to as isocyanates. An organic compound with two isocyanate groups is known as a disiocyanate. Disiocyanates are manufactured for the production of polyurethanes, a class of polymers [4]. The reaction to prepare polyurethane as in the equation below.

Polyurethane manufactured alone in the form of a sandwich panel that is combustible when exposed to a process of flame or electric spark, which leads to disasters when building halls, stores or houses. Therefore, studies were directed to address these problems by introducing additives to polyurethane so that it is resistant to combustion [5-9].
2. Experimental work

Polyurethane foam was prepared consisting of polyol and isocyanate manufactured by the German company Bayer. The urea used is Iraqi-made, while the polyvinyl used is Chinese-made from the Chinese poly vinyl alcohol (PVA)-1600 company. The urea powder was prepared after dissolving it with water and adding 2% polyvinyl, then drying at a temperature of 50°C, grinding and sieving using a sieve less than 150μm as followed in the research [10].

Samples were prepared of polyol and isocyanate at a percentage of 50% for each of them, where the polyol was first placed in the mold (cylindrical metal molds with a diameter of 5.06cm and a height of 10cm), and urea powder was added and mixed well manually, and then the isocyanate was added and conduct a quick and good mixing process, and then leave the samples in the molds for a short period of time to complete the chemical reaction and dry the samples within the mold, and then the samples is taken out from the mold. Table 1 shows the mixing ratios for preparing samples and the prepared samples are illustrated in Figure 1.

3. Results and discussion

For the preparation of polyurethane, the nature of the chemical reaction of polyol and isocyanate was exothermic reaction, and the added urea did not dissolve, but remained widespread in the prepared samples, and the prepared samples without adding urea was fragile and breakable, and the more percentages of urea were added, the samples became flexible and unbreakable, but when the percentage increased more from 5.5 the samples become loose and can rupture easily.

Figure 2 shows the change in the density of polyurethane with urea percentages and shows an increase in the amount of density in an almost straight line, and Figure 3 shows the change in the thermal conductivity of polyurethane with urea percentages, and the figure shows a clear decrease in the amount of thermal conductivity with the increase in urea percentages and this effect very useful in protecting rooms or warehouses from heat transfer, and this can be explained by the increase in the percentage of urea. The percentage or number of pores increased, but their size decreased, and thus the thermal conductivity decreased [11-13].

Figure 4 Samples were prepared for the purpose of exposing them to direct fire on the cooker's flame. The samples show the combustion of the urea-free model, and the higher the percentage of urea, the greater the resistance of the non-combustion samples. The best samples were between the urea ratios 4.5 to 6, and the best in terms of durability, cohesion, flexibilities and fire resistance could be adopted is the ratio of 5g of urea per 12 cubic centimeters of polyurethane. The addition of urea improved the prepared samples in terms of cohesion, flexibility and fire resistance.

Table 1. Shows the mixing ratios for sample preparation

| Urea 98% + PVA 2% (wt) | Polyl (ml) | Isocyanate (ml) |
|------------------------|-----------|-----------------|
| 0                      | 6         | 6               |
| 0.5                    | 6         | 6               |
| 1                      | 6         | 6               |
| 1.5                    | 6         | 6               |
| 2                      | 6         | 6               |
| 2.5                    | 6         | 6               |
Table 1. Polyurethane density with urea percentages

| Urea Percentage (%) | Density (g/cm³) |
|---------------------|----------------|
| 3                   | 6              |
| 3.5                 | 6              |
| 4                   | 6              |
| 4.5                 | 6              |
| 5                   | 6              |
| 5.5                 | 6              |
| 6                   | 6              |

Figure 1. Prepared samples

Figure 2. The change of polyurethane density with urea percentages
4. Conclusion

The addition of urea to polyurethane improved the properties of polyurethane in terms of giving it excellent flexibility, as well as a decrease in the value of thermal conductivity, as well as flame and fire resistance, and the best ratio was 5g of urea per 12cm$^3$ of polyurethane.

5. References

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