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Short communication

Manufacturing of urea–formaldehyde-based composite particleboard from almond shell

M. Gürü [a,*], S. Tekeli [b], İ. Bilici [c]

[a] Gazi University, Faculty of Architecture, Chemical Engineering Department, Maltepe, 06570 Ankara, Turkey
[b] Gazi University, Metallurgy Education Department, Besevler, 06500 Ankara, Turkey
[c] Gazi University, Chemical Engineering Department, 19030 Çorum, Turkey

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Abstract

The purpose of present study was to investigate a cheap method to manufacture particleboard. The experiments were carried out using almond shell that had no economical value other than being used merely as low grade fuel and fodder. The parameters affecting composite particleboard production from almond shell and urea–formaldehyde were determined to be urea–formaldehyde ratio, reaction temperature, reaction time and almond shell particle size and the effect of these parameters on hardness and bending strength were investigated. The experimental results showed that maximum hardness and bending strength were 97.5 Shore A and 84.52 N/cm^2, respectively, at a urea–formaldehyde ratio of 0.97, reaction temperature of 70 °C, reaction time of 25 min and mean particle size of 0.3 mm.

Keywords: Urea–formaldehyde; Particleboard; Almond shell; Hardness and bending strength

1. Introduction

High demand for wooden materials and rises in agricultural areas and forest fires increased the importance of composite particleboard instead of using solid woods. Particleboards are among the most popular materials used in interior and exterior applications in floor, wall, ceiling panels, office dividers, bulletin boards, cabinets, furniture, counter and desk tops [1]. The extensive use of particleboards can be related to the economical advantage of low cost wood raw material, inexpensive agents and simple processing. Agricultural residues are used widespreadly for manufacturing of particleboards. Among the raw materials are pomace [2,3], kiwi prunings [4], wheat straws [5], bamboo [6], cotton seed hulls [7], flax shiv [8], rice straw-wood [9], vine prunings [10], coir pith [11], and wood flour [12]. Urea–formaldehyde, phenol–formaldehyde, polyethylene and polyvinylidene are extensively used as a binder. Among these binders, urea–formaldehyde is the most economic and useful glue because of its low cost and easy production.

The aim of the present study was to determine the effects of urea/formaldehyde ratio, reaction temperature, reaction time and almond shell particle size on hardness and bending strength of composite particleboard produced from almond shell.

2. Material and methods

The experimental set-up for the urea–formaldehyde reaction consisted of a spherical flask reactor, a reflux condenser, a thermometer and a heating mantle with a magnetic stirrer. A 1000-ml three necked volumetric

* Corresponding author. Tel.: +90 312 2317400/2555; fax: +90 312 2308434.
E-mail address: mguru@gazi.edu.tr (M. Gürü).

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pyrex flask was used as a reactor. The purity of chemicals reacted for the production of urea–formaldehyde binder were 37% formaldehyde solution and 99.99% urea. Concentrated NaOH solution was used as a catalyst in the reaction. Almond shells were employed throughout the study as a filler material. Almond shells were first ground, sieved and dried in oven at 105 °C for about 1 h.

Depending on the parameters of each trial, 6 ml concentrated NaOH catalyst solution and urea were added to 30 g heated formaldehyde solution. Reaction temperature was controlled within ±2 °C by thermostat. After the polymerization reaction had been completed at specified temperature and time, filler material was added into the polymer until it was saturated and the mixture was then cast into a mould and dried for 24 h at atmospheric conditions. The cast material was removed from the mould, turned of opposite side and dried again for 24 h. Finally, it was dried at 70 °C in an oven until constant weight was reached. In order to see how the conditions in the reactor affected the mechanical properties, urea/formaldehyde ratio, reaction temperature and time and filler material particle size were chosen as parameters.

Mechanical properties were determined by means of hardness and bending tests. Shore A hardness tests were carried out using a Durotech M202 hardness tester. Shimadzu AG-I was used for three points bending tests. For three point bending test, the span length was 27 mm and the cross head speed was 10 mm/min. The dimension of the rectangular specimen was 15-mm high, 23-mm wide and 50-m long. Before testing the edges of the surface of specimens undergoing tensile stresses were beveled at 45° to avoid the fracture from the specimen edges. A minimum of five specimens for bending tests and ten different points on each specimen for hardness tests were carried out in order to establish average values. Scanning electron microscopy (SEM, JEOL 6360) was used to characterize the microstructure of specimens.

3. Results and discussion

The effect of processing parameters, namely urea/formaldehyde ratio, reaction temperature, reaction time and shell particle size were investigated and optimum values were determined. To determine the optimal urea/formaldehyde ratio, a resin containing various ratio of urea/formaldehyde was prepared. The effect of urea/formaldehyde ratio on hardness of composite particleboard was investigated at reaction temperature of 65 °C, reaction time of 20 min and mean particle size of 0.6 mm. The relationship between hardness and urea/formaldehyde ratio is shown in Fig. 1. The hardness values increased linearly with increasing urea/formaldehyde ratio up to 0.97 and further increase in urea/formaldehyde ratio caused slight hardness decrease. The increase in the hardness with an increase in urea/formaldehyde ratio was as a result of developing urea formaldehyde reaction, whereas slight decrease in hardness after 0.97 was due to the insufficient formaldehyde. Trial-and-error experiments to find out the optimum urea/formaldehyde ratio showed that urea/formaldehyde ratio of 0.97 corresponding to highest hardness value was a reasonable choice and it was recorded as a constant parameter in the further experiments.

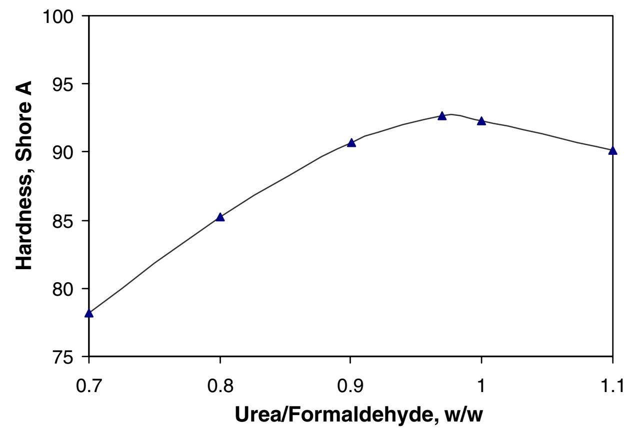

Fig. 1. Effect of urea/formaldehyde ratio on the hardness of composite particleboard.

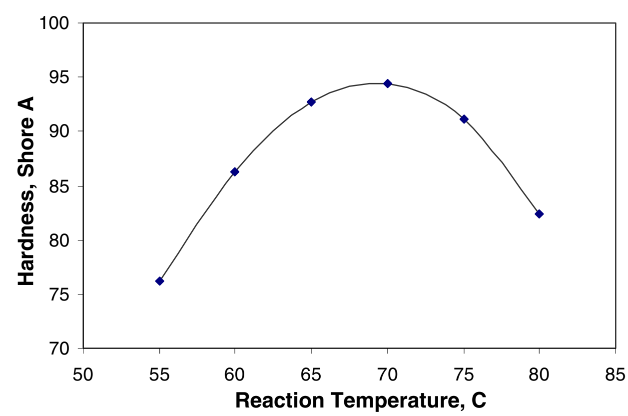

Fig. 2. Effect of reaction temperature on the hardness of composite particleboard.

For the determination of optimal reaction temperature (varying from 55 to 80 °C), a fixed urea/formaldehyde ratio of 0.97 and reaction time of 20 min were used and the optimum hardness was defined by changing the reaction temperatures. Fig. 2 shows the relationship between hardness and reaction temperature. It is evident from Fig. 2 that the hardness values increased with increasing reaction temperature up to 70 °C and then decreased with further reaction temperature increase. It can be deduced from the experimental results that the reaction temperature up to 70 °C affected the