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An environmentally friendly thermal insulation material from sunflower stalk, textile waste and stubble fibres

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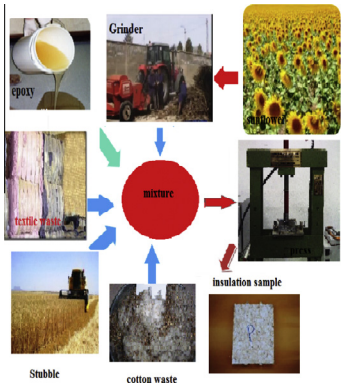
HIGHLIGHTS

- Heating costs in winter and cooling costs in summer is very high.
- To reduce heating and cooling costs are building insulation.
- Sunflower production in Turkey carried out a significant amount.
- This type of use is causing serious problems in the environment.
- The use of waste materials to produce a new insulation material.

GRAPHICAL ABSTRACT



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ABSTRACT

Heating costs in the winter and cooling costs in the summer are very high. Building insulation reduces heating costs in the winter and cooling costs in the summer. Although sunflower production in Turkey is significant, after the production the sunflower stem is a serious problem for farmers. Sunflower stems are cleaned, burned or used for temporary heating purposes. This type of use is causing serious problems to the environment. Sunflower stalks and cotton textile waste, such as stubble, cause serious environmental problems. To circumvent this problem, the present study puts forth an advantageous use of those waste materials for insulation of buildings. In Turkey there are a lot of both of the aforementioned materials. As the binder for those two materials epoxy was used. As samples, 30 × 40 × 2.5 cm rectangular blocks were prepared under different pressures. The samples were tested for their mechanical properties and the coefficients of thermal conductivity, as well. The results obtained satisfied the Turkish Standard TS 805 EN 601. Thus, the method proposed in this study solves two industrial problems at the same time. A useful construction material is produced while some waste materials causing environmental problems are warded off.

1. Introduction

Insulation materials in buildings have become widely used since the beginning of the 20th century. The new building and construction systems provide many benefits and some drawbacks in terms of building physics and the conditions of comfort that emerge as time passes. The exterior walls must be thin to prevent

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Fig. 1. Cotton waste.

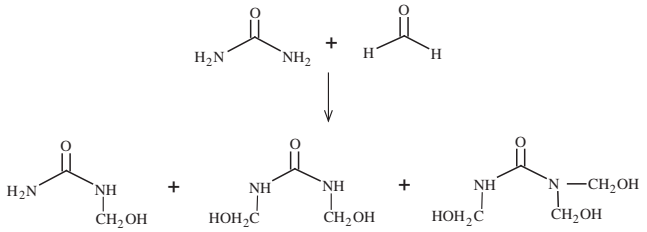

Fig. 3. Formation of mono-, di-, and trimethylolurea by the addition of formaldehyde to urea.

Table 1
Potential of agricultural waste in Turkey [14].

Agricultural residues	Annual production (million tonnes)
Sunflower stalks	2.7
Wheat stalks	26.4
Barley grips	13.5
Corn stalks	4.2
Cotton stalk and cocoons	2.9
Sugar beet grips	2.3
Hazelnut shells	0.8
Oats grips	0.5
Rye grips	0.4

the load carrier system [1]. In recent years, energy resources have rapidly decreased. Approximately 40% of the energy is spent on buildings in Turkey [2]. Although the total energy consumption per capita in the last 25 years has increased by 5%, this ratio has increased by over 100% in Turkey [3] due to the energy consumption to heat uninsulated houses with an average of 200 kW h/m^2 per year. Heating houses requires financial resources of 3.5 billion dollars. Today, the cost of the energy required for the heating of houses is estimated to be more than 4 billion dollars. The calculations made by the isolation of the entire building stock according to the existing standards shows energy savings of over 2 billion dollars per year. Therefore, the use of insulation materials has become a necessity. The production of appropriate materials for insulation materials is of great importance. Insulation materials are usually produced from inorganic materials. In recent years, these materials have been prohibited due to the suspicion of health risks Thus, it is important to investigate organic-based insulation materials. Mengeloglu and Alma [4] studied intensive technological developments and solved production problems with wheat stalks, which led to the successful production of composite panels. Wheat straw particle board and fibre boards have been found to be more advantageous than others. In Turkey, there is a significant amount of sunflower production. There are 2,500,000 tons of waste per year in the form of sunflower stalks, which is a serious problem for farmers growing sunflower stalks. Monika et al. [5] determined the coefficients of thermal conductivity of composites obtained by using natural fibres. The results for these composites are lower than the heat transfer coefficients of artificial fibres, and they are more economical, do not harm the environment, and have better mechanical properties. However, the wheat stubble remaining in the fields after harvesting is significant, and the environmental pollution is caused by the incineration of waste [6].

Most of the farmers burn the stubble after harvest due to the lack of economic value of wheat stalks. The burning stubble represents a loss of national wealth and destroys soil micro-flora in addition to polluting the atmosphere. Approximately 40% of cereal stubble fields in Turkey are burned every year and 10 million tons of exposed stalks and straw disappears. As a result, the release of smoke and carbon dioxide into the atmosphere causes global warming. However, the use of lignocelluloses has a long history. In ancient Egypt, adobe mud mixed with straw was used. In the experimental studies, it was found to have a much lower coefficient of heat conduction than mud bricks [7].

Cristel et al. [8] changed the ratio of vegetable fibre in cement composites. The vegetable fibres produced a slight decrease in the thermal conductivity, and the mechanical strength of the composites increased. In addition, the use of more fibre composites can reduce weight and reduce the coefficient of thermal conductivity. Zhou et al. [9] manufactured an environmentally friendly heat insulation material using a resin and cotton stalks. The cotton stalk fibres created an insulation material that can compete with others.

The thermal insulation properties of fabrics formed from natural and synthetic fibres are compared. Artificial fabrics composed of cotton based fabrics that have a lower value than the corresponding thermal conductivity, thermal absorption, and thermal diffusion resistance were found in the study. In addition, the thermal insulation characteristics of the type of weaving are effective [10]. Briga-Sá et al. [11] investigated the feasibility of fabric waste as a heat insulation material. It appears to be an adequate solution as a possible heat insulation material to recycle these wastes, and environmental sustainability and economic benefits may result from these applications.

Binici et al. [12] studied a new insulating material produced by light cotton waste and textile ash and investigated the properties of the materials produced. In another study, cotton waste, fly ash, and light building materials manufactured with epoxy resin could be used as thermal and acoustic insulation materials [13].

As shown in previous studies, waste is of great importance in our world now. The use of alternative waste due to the rapid

Fig. 2. Sunflower stalks.