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Research Article / Araştırma Makalesi

IMPROVEMENT OF WATER-BASED INTERIOR DYES PREPARED BY USING NATURAL MINERAL AND FIBER INDUSTRIAL PLANT

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ABSTRACT

In this study, natural minerals and industrial fibrous plant waste were supplied from various regions of Turkey unlike from the literature. Dye application was carried out with 200 µm applicator on standard sizes (10 cm x 10 cm) of metal surfaces. The dyed this original mixture was applied on the block and panel building materials. Dyes were examined according to the features of unaffected by water, not changed the nature and physical strength, high concealer effect in detail. As a result, the optimum process parameters (for two different natural minerals and the amount of industrial fibrous plant waste) were determined. The statistical method was used and the results obtained were analyzed comparatively in terms of improving both cost and quality for determination of optimum process parameters. In conclusion, the test results (concealer property, hydrophobicity, impact and adhesion tests) and results showed that the usage of natural minerals and industrial fibrous plant waste effected the production of insulated interior dye, positively.
Keywords: Dye, waste, mineral, insulation.

DOĞAL MİNERAL VE ENDÜSTRİYEL LİFLİ BİTKİ KULLANILARAK HAZIRLANAN SU BAZLI İÇ CEPHE BOYALARININ GELİŞTİRİLMESİ

ÖZ

Bu çalışmada, literatürden farklı olarak, Türkiye'nin çeşitli bölgelerinden doğal mineraller ve endüstriyel lifli bitki atıkları temin edilmiştir. Standart boyutlarda (10 cm x 10 cm) kesilmiş metal yüzeyler üzerine 200 µm'lik aplikatör kullanılarak boya uygulaması gerçekleştirilmiştir. Üretilen bu özgün karışımlı boya, blok ve panel yapı malzemeleri üzerine uygulanmıştır. Boyalar, sudan etkilenmemesi, doğasının ve fiziksel dayanıklılığının değişmemesi, yüksek kapatıcılığa sahip olması gibi özelliklerine göre detaylı olarak incelenmiştir. Optimum proses parametreleri (iki farklı doğal mineral ve endüstriyel lifli bitki atıkları için) belirlenmiştir. Gerek maliyet gerekse kaliteyi geliştirmek açısından optimum proses parametrelerinin belirlenmesinde istatistiksel metot kullanılarak, elde edilen sonuçlar karşılaştırmalı olarak incelenmiştir. Yapılan test sonuçlarına göre (kapatıcılık özelliği, hidrofobiklik, darbe ve yapışma testleri) doğal minerallerin ve endüstriyel lifli bitki atığı kullanımının, yalıtımlı iç cephe boya üretiminde olumlu bir etkisinin olduğu görülmüştür.
Anahtar Sözcükler: Boya, atık, mineral, yalıtım.

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1. INTRODUCTION

Producing energy with indigenous, renewable resources and the trends for increasing energy efficiency are of great importance about the supply of energy for a large extent dependent on foreign countries as our country. Overall, insulation materials are grouped as organic foamed material and inorganic fibrous material in the European market. Although these materials show similar insulation properties, they have important differences. In addition, insulation materials cause certain amount of raw material, water, energy, chemical consumption and waste, waste water production during the production stage of insulating materials. For this reason, in many applications, it is observed that insulating materials have contributed significantly to the process of the life cycle. In Turkey, there are a lot of aforementioned materials. Especially, epoxy is used as the binder. A useful construction material is produced while some waste materials causing environmental problems are warded off [1]. An experimental work concluded that there were significant similarities between the corn's cob and the extruded polystyrene material in terms of microstructure and chemical composition. Furthermore, the results obtained from an expeditious experimental thermal procedure indicate that the corn's cob had adequate thermal properties for building purpose. Corn's cob was found as a component of external walls in ancient buildings [2]. Briga-Sá et al. (2013) was studied the potential applicability of woven fabric waste and a waste of this residue, named woven fabric subwaste, as thermal insulation building material. Surface temperature sensors were placed on the wall surface to determine the thermal conductivity of the wastes. The obtained results show that the application of the woven fabric waste and woven fabric subwaste in the external double wall increases its thermal behavior in 56% and 30%, respectively [3].

The European market of insulation materials was characterised by the domination of two groups of products inorganic fibrous materials and organic foamy materials. Environmental and public health aspects played an increasing role, both in the search for optimum materials [4]. Papadopoulos and Giama (2007) examined the building's environmental performance through the insulation's material selection. Contemporary insulation materials achieve thermal conductivity values of less than 0.04 W/mK [5]. Mahlia et al. (2007) studied the correlation between thermal conductivity and the thickness of selected insulation materials for building wall has been analyzed. The study has found that a relationship between the thermal conductivity and optimum thickness of insulation material is non-linear and proper to a polynomial function. This relationship was very useful for practical use to estimate the optimum thickness of insulation material in reducing the rate of heat flow through building wall by knowing its thermal conductivity [6].

With regard to organic and mineral-based insulation, fibers, flax and hemp were used as heat insulation materials in literature. The purpose of the study was to evaluate the suitability of flax and hemp fibers for thermal insulation [7]. In another study, the addition of hardened molasses binder and pumice lightweight, insulated brick production possibility was examined in detail with experimental data. The results of the research showed that it was possible to produce insulated and water-resistant bricks by using cement, plaster perlite and pumice [8].

The researchers were studied about the roles of hydrophilicities and hydrophobicities of dyes on the photochemical pathway. As a result, the use of a hydrophobic couple of both dye and sacrificial electron donor, as well as a hydrophilic couple of both dye sacrificial electron donor [9]. In another study, characterizations of surface hydrophobicity of engineered nanoparticles for dyes were searched and the advantages and limitations of each method were also discussed [10]. In experimental studies, there are various optimization methods in literature. Taguchi is a method in significant quality improvement in product and manufacturing process design. Taguchi uses signal-to-noise ratios, orthogonal arrays, linear graphs, and accumulation analysis. For analyzing experiments, this approach shows additional information about how control factor settings the effects of individual noise factors; this helps engineers better under stand die physical mechanism of the product or process [11].

In this study, insulation materials have been examined in order to determine parameters for thermal insulation on the water-based interior dye. Pumice, zeolite and nutshell 0-6% (in terms of dye, w/w) was added to water-based dyes. According to Taguchi L-9 orthogonal array, the experiments were selected at three parameters and three levels in 9 different dye contents. Moreover, some visual tests was applied on wet and dry dye. Insulation percentages were calculated for 9 different experiments by using results of thermal conductivity measurement. In conclusion, it was seen that the usage of natural minerals and industrial fibrous plant waste effected the production of insulated interior dye and hydrophobicity.

2. EXPERIMENTAL

2.1. Materials

Pumice was supplied by Nevsehir region in Turkey. Nutshell, zeolite were provided from Blacksea region and Eti Maden Works General Management, respectively.

2.2. Methods

The pumice, nutshell and zeolite as isolation materials were used in range of 0-6% (in terms of dye, w/w). The dye, pumice, nutshell, zeolite for isolation were homogenized by using mechanical stirrer (Figure 1). The dye with the isolation materials was stirred at 1000 rpm for 3 minutes. The applicator film thickness was used with 200 μm (Figure 2). Zebra papers (the surface chequered with black and white colours) were used for the concealer property test. Hydrophobicity and adhesion tests were performed to surfaces of plates. Isolation values were calculated with heat conductivity values of dyes prepared. Taguchi method (L-9 orthogonal array table) was used to carry out experiments.

Figure 1. Preparation of dye

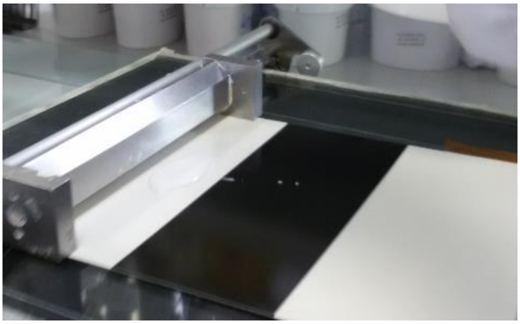

Figure 2. Zebra paper by using interior dye

3. RESULTS AND DISCUSSION

3.1. Taguchi Method

Taguchi method developed a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only [12]. The Taguchi method is the conventional approach used in off-line quality control. However, most previous Taguchi method applications have dealt only with a single-response problem. The multi-response problem has received only limited attention. Proposes an effective procedure on the basis of the quality loss of each response so as to achieve the optimization on multi-response problems in the Taguchi method [13].

The experimental results are transformed into a signal-to-noise (S/N) ratio. This method uses the S/N ratio as a measure of quality characteristics deviating from or nearing to the desired values. There are three categories of quality characteristics in the analysis of the S/N ratio, for example, the lower the better, the higher the better, and the nominal the better. The formula used for calculating of S/N ratio was given below [14] as Figure 3:
Smaller the better: It is used where the smaller value is desired as Eq. (1).

$$\text{S/N ratio } (\eta) = -10 \log_{10} \frac{1}{n} \sum_{i=1}^{n} y_i^2 \tag{1}$$

where yi = observed response value and n = number of replications. Nominal the best: It is used where the nominal or target value and variation about that value is minimum as Eq. (2).

$$\text{S/N ratio } (\eta) = -10 \log_{10} \frac{\mu^2}{\sigma^2} \tag{2}$$

where μ = mean and σ = variance. Higher the better: It is used where the larger value is desired as Eq. (3).

$$\text{S/N ratio } (\eta) = -10 \log_{10} \frac{1}{n} \sum_{i=1}^{n} \frac{1}{y_i^2} \tag{3}$$

where y_i = observed response value and n = number of replications. Taguchi showed a standard procedure for optimizing the process parameters [15].

In this study, Taguchi method was performed for 3 parameters and 3 levels at 9 different experiments (Table 1). Thermal conductivity value for raw materials to calculate isolation percentages were obtained convenient as previous study [16, 17].

Table 1. Taguchi method

No	Pumice levels*	Nutshell levels*	Zeolite levels*
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

* for levels: Level 1: 0%; Level 2: 3%; Level 3: 6% (in terms of dye, w/w)

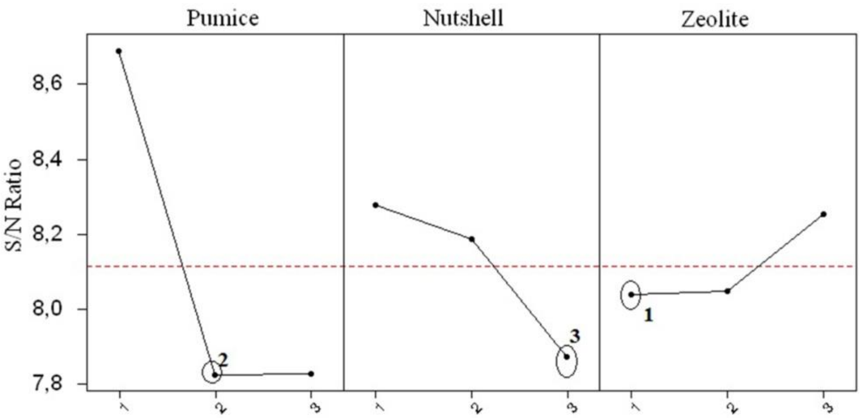

Figure 3. Main effects plot for S/N ratios [18]

3.2. Concealer Property

Additives that used enhanced concealer property of dyes. Concealer property result was shown in Figure 4 for off-white colour water-based interior dye.

Figure 4. Concealer property

3.3. Hydrophobicity Test

0.1 ml waterdrop, was dropped by pipette onto the dry dye film in the aluminum plate, has been brought to the upright position slowly after waiting 3 hours. It has seen that the water was flowed smoothly from the dye film surface for all samples and it was not observed any discoloration, lifting, wrinkling or softening. Wettability is an important property of solid surfaces from both fundamental and practical aspects. However, various industrial products require not only hydrophilicity but also hydrophobicity. Given the limited contact area between solid surface and water, chemical reactions or bonding formation through water are limited on a super-hydrophobic surface [19, 20]. As a result, surface was hydrophobic in the dry dye film. (Figure 5).

Figure 5. Hydrophobicity test

3.4. Adhesion Test

Adhesion test, that performed water-based dyes by applying 10x10 cm aluminum plates results was seen in Figure 6. Adhesion is shown to depend on the interfacial surface energy and on the geometry and elastic constants of the adherent bodies [21]. In the adhesion test, the dry dye film of 1.5-2 cm long 45° angle on the two diagonals and the line was drawn on the side edges 135° angle in facing relation of adhesive tape. Air bubbles between the fingers panel rubbing was resolved. Releasing a tip end of the adhesive tape held by the tape was drawn perpendicular to the surface with a jerk. As a result of the adhesion tests, scratches edges fully uniform, none of the square formed by combing shedding was observed.

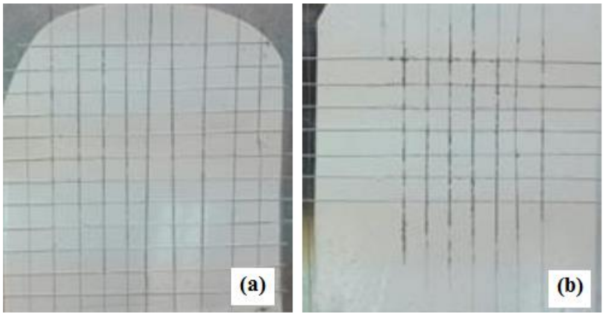

Figure 6. Adhesion test: (a) Before, (b) After

3.5. Impact Test

The application of metal ball thrown to a certain height was applied onto the plate for the impact test in Figure 7. In the experimental results, it was not shown any deterioration in plate.

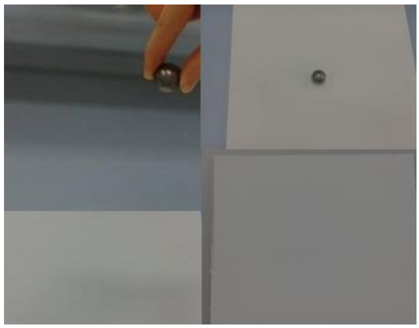

Figure 7. Impact test

All test results for water-based interior dye were given in Table 2.

Table 2. Test results

No	Concealer property	Hydrophobicity Test	Adhesion test	Impact test
1	+	+	+	+
2	+	+	+	+
3	+	+	+	+
4	+	+	+	+
5	+	+	+	+
6	+	+	+	+
7	+	+	+	+
8	+	+	+	+
9	+	+	+	+

4. CONCLUSION

Consequently, the optimum thermal insulation was determined by using Taguchi method for 3 parameters and 3 levels. The optimum mixture was experiment 6 for 2-3-1 in Taguchi method. 30.47% was obtained as the maximum isolation value. Isolation percentages, concealer property, hydrophobicity and adhesion test results showed that the usage of natural minerals and nutshell as industrial fibrous plant waste effected the production of insulated interior dye.

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