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Environmental Function Evaluation and Preparation of Green Decorative Materials in Indoor Design

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ABSTRACT

With the growing environmental awareness, there is a rising demand for green decorative materials in furniture and indoor design. However, the existing studies lack the overall evaluation of environmental functions for green decorative materials in indoor design. To make up for the gap, this paper evaluates the environmental function and explores the preparation method of green decorative materials in indoor design. Firstly, the types and purchase principles of green decorative materials were expounded, and the preparation flow of wood product coating was given for green decorative materials in indoor design. Then, an evaluation model was established for the environmental functions of green decorative materials, the stochastic dominance matrix was constructed for the indices, and the order value of each index was computed. Finally, fuzzy Dempster–Shafer (D-S) evidence theory was adopted to develop a prediction algorithm for the environmental function of indoor decorations, and thus realize the evaluation of the greenness of decorative materials in indoor design. Experimental results demonstrate the effectiveness of our algorithm, and the good performance of the prepared super-hydrophobic and oleophobic coatings.

1. INTRODUCTION

As a result of social-economic integration, personalized interior design not only brings comfort and beauty, but also seriously pollutes the indoor environment. In future, consumers will pursue greener, more environmentally-friendly, and more efficient decorative materials for indoor design [1-4]. The greening of indoor decorations helps to improve the living environment and the health condition [5-7]. Visually speaking, green indoor decorative materials can improve the mood of the occupants, and even relieve fatigue [8-15]. With the growing awareness of health, there is a rising demand for green decorative materials in furniture and indoor design [16-19]. In recent years, various green decorative materials with diverse functions have been researched and developed. This trend testifies the surge in the demand for indoor green decorative materials.

Ling [20] noted that the functions and environmental friendliness of indoor decorative nanomaterials are the current research hotspot, carried out three survey experiments on the role of decorative nanomaterials in indoor design and the application of environmental protection concepts, and compared the environmental parameters of traditional decorative materials and those of green nanomaterials. The experimental results show that indoor decorative design with green nanomaterials reduces the emissions of harmful and toxic materials. Taking a construction project as the object, Lu [21] monitored the gaseous pollution (e.g., hydrogen sulfide and sulfur dioxide), solid pollution, water pollution, light pollution and noise pollution sources in the construction site, and demonstrated that high-quality construction of green buildings can be realized through overall design of energy conservation and environmental protection, the structural optimization design, and heating, ventilation, and air conditioning (HVAC) design of green buildings. Wang and Li [22] combined high-performance phase change composites with the system of energy-saving green indoor decorative materials into a temperature-automatically controlled energy-efficient green decorative material system based on phase change composites. Ryder [23] pointed out the development trend of modern building materials (traditional building materials cannot meet people's needs, while new environmentally friendly building materials can satisfy our demand), and detailed the new green construction materials and their applications. Li [24] described a series of commercial processes for indoor design coatings, which are pollution-free, low-cost, fast to apply, and user friendly, with a small capital/equipment cost.

The existing studies lack the overall evaluation of environmental functions for green decorative materials in indoor design. This paper probes deep into the functions, roles, and preparation of green decorative materials from the following aspects: the development of green decorative materials, the different types of green decorative materials, the environmental functions of green decorative materials in indoor space, and the limitations and prospects of the application of green decorative materials. Starting from the current state of household-based indoor green decorative materials in modern cities, this paper mainly involves the following contents: Section 2 expounds the types and purchase principles of green decorative materials, and specifies the preparation flow of wood product coating for green decorative materials in indoor design. Section 3 establishes an evaluation model for the environmental functions of green decorative materials, constructs the stochastic dominance matrix for the indices, and computes the order value of each index. Section 4 adopts fuzzy Dempster–Shafer (D-S) evidence theory to develop a prediction algorithm for the environmental function of indoor decorations, and thus realize the evaluation of the greenness of decorative materials in indoor design. Experimental results demonstrate the effectiveness of our algorithm, and the good performance of the prepared super-hydrophobic and oleophobic coatings.

2. TYPES AND PURCHASE PRINCIPLES OF GREEN DECORATIVE MATERIALS

Common green decorative materials include soft stone floor, integrated wallboard, green wall facing, latex paint, diatomaceous earth, etc. The stone floor, which is mixed from natural marble powder and other polymers, boasts a rich texture, a good quality, as well as high greenness, energy-efficiency, and recyclability. Currently, the popular integrated wallboards are mainly made of nanofibers, bamboo fibers and Al-Mn alloy. These materials have advantages in terms of insulation, fire prevention, moisture-proof, environmental performance, wear resistance, and convenient installation. The grass wallpaper and hemp wallpaper in the market have good moisturizing, anti-mildew and peeling effects. These two green decorative materials win the favor of consumers for their rich colors and beautiful appearance. Latex paint is aqueous decorative paint, with a certain moisture-proof and anti-mildew effect. This beautiful and scrub-resistant product has been widely used on interior walls. Diatomaceous earth is also favored in indoor decorative design, owing to its excellent environmental performance, flame retardancy, sound absorption ability, and good air purification effect.

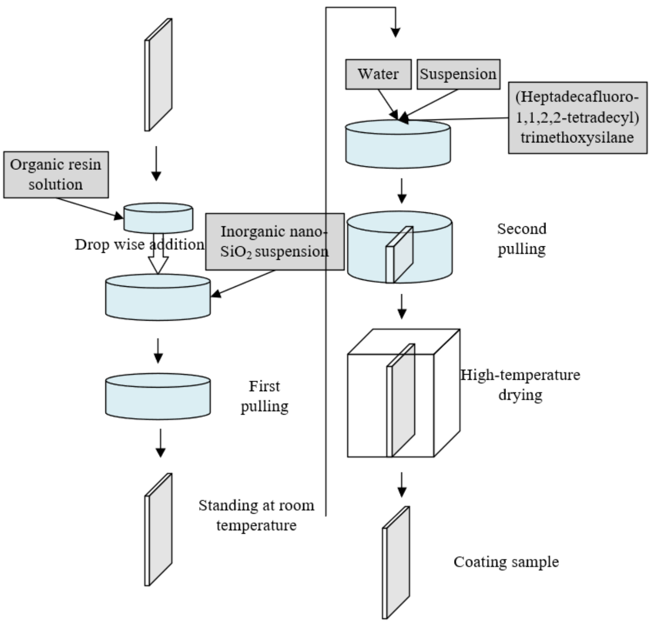

Figure 1. Preparation flow of wood product coating for green indoor decoration

During the purchase of green decorative materials, the walls should be decorated with wooden boards as much as possible, applied with pollution-free polyvinyl chloride (PVC) green wallpapers, or painted with smooth aqueous coatings. The preferred floor material is pollution-resistant and nonradioactive natural stones. If solid wood flooring is adopted, the glue must have low organic emissions. The wood products need to be coated with green coatings. Never use odorous benzene-containing diluents that volatile rapidly.

Wood product coatings are shifting from solvent coating to green coating. Green aqueous coatings are less harmful to the human body than powder coatings and curable coatings. This paper explains the preparation flow of a super-hydrophobic and oleophobic coating for green indoor decorations (Figure 1), aiming to transcend the constraint of drying condition on coating production, reduce the use of highly toxic organic solvents, and improve the durability and aesthetics of the coating material.

Indoor decoration is directly associated with the health and safety of consumers, and concerned by all walks of life. Strictly speaking, it is difficult to clearly define whether a green decorative material is to be applied indoor, outdoor, or in special venues. Therefore, this paper, focusing on green indoor decorative materials, firstly evaluates the environmental functions of green decorative materials, and then discusses the preparation technique of the super-hydrophobic and oleophobic coating.

3. MODEL CONSTRUCTION

3.1 Stochastic dominance matrix

Let R_i be type i green decorative material. Then, the set of u types of green decorative materials can be denoted as $R=\{R_1,R_2,...,R_i,...,R_n\}$. Let FZ_j be an evaluation index of the environmental functions of green decorative materials. Then, the set of m such indices can be denoted as $FZ=\{FZ_1,FZ_2,...,FZ_i,...,FZ_m\}$. Based on the calculation of greenness, the environmental function levels of an index FZ_j can be determined as $\psi^\tau=\{\psi^1=1, \psi^2=2, \psi^3=3, \psi^4=4,\psi^5=5\}$.

The stochastic dominance between the indices FZ_1, FZ_2, ..., FZ_l, ..., FZ_m can be determined as follows: Firstly, the cumulative probability distribution functions (CPDFs) of all random variables, which bear on the values of the evaluation indices, are compared randomly by the optimal allocation principle of stochastic dominance. Then, the all indices can be ranked by superiority/inferiority.

To begin with, it is necessary to compute the expectation p_S of the CPDF $G_S(\varphi)$ of the environmental function levels corresponding to the greenness scores of green decorative material R_i on all indices. Contraposing expert comment set D, the number of expert comments on green decorative material R_i, which assign the environmental function on index FZ_j to level ψ^τ, is denoted as CO^τ_{ij}. According to CO_{ij} and CO^τ_{ij}, the probability for the environmental function of green decorative material R_i on index FZ_j to fall on level ψ^τ can be calculated by:

$$pro_{ij}^{\tau}=\frac{CO_{ij}^{\tau}}{CO_{ij}} \tag{1}$$

Let $G_{ij}(\varphi)$ be the CPDF of environmental function of green decorative material R_i on index FZ_j; $G_{if}(\varphi)$ be the CPDF of the environmental function of green decorative material R_i on index FZ_f falling on level ψ^τ. When $G_{ij}(\varphi)$ has stochastic dominance over $G_{if}(\varphi)$, FZ_j must have stochastic dominance over FZ_f. The CPDF of the environmental function of green decorative material R_i on index FZ_j falling on level ψ^{τ} can be given by:

$$G_{ij}(\phi) = \sum_{\phi \geq \psi^{\tau}} \overset{\tau}{\underset{ij}{Pro}} \tag{2}$$

On this basis, it is possible to construct the expected vector $P_i=(p_{ij})_{i*1}$ for the environmental function level of green decorative material R_i on index FZ_j, where p_{ij} can be defined as:

$$p_{ij}(\phi) = \sum_{\tau=1}^{5} \underset{ij}{Pro} \, \psi^{\tau} \tag{3}$$

Next, it is necessary to construct the stochastic dominance matrix s^i_{jf} between any two indices of green decorative material R_i. The comments of all experts are converted into the probability distributions of the environmental function levels of the green decorative material on the indices. After that, any two indices of green decorative material R_i are compared by the stochastic dominance rule. The stochastic dominance $S_i=(s^i_{jf})_{Mzt\times Mst}$ between indices FZ_j and FZ_f of green decorative material R_i can be characterized by:

$$s^i_{jf} = \begin{cases} FOR, G_{ij}(\psi^{\tau}) FORG_{if}(\psi^{\tau}) \\ SOR, G_{ij}(\psi^{\tau}) SORG_{if}(\psi^{\tau}) \\ TOR, G_{ij}(\psi^{\tau}) TORG_{if}(\psi^{\tau}) \\ /,\ Otherwise \end{cases} \tag{4}$$

where, $s^i_{jf}=FOR$ means index FZ_j of green decorative material R_i has first-order stochastic dominance over FZ_f; $s^i_{jf}=SOR$ means index FZ_j of green decorative material R_i has second-order stochastic dominance over FZ_f; $s^i_{jf}=TOR$ means index FZ_j of green decorative material R_i has third- order stochastic dominance over FZ_f; $s^i_{jf}=/$ means stochastic dominance does not exist between indices FZ_j and FZ_f.

3.2 Oder value of indices

(1) Matrix of stochastic dominance degrees

Based on the constructed stochastic dominance matrix $S_i=(s_{jf})_{Mzt\times Mst}$, an order function is established by hesitant fuzzy method to further depict the stochastic dominance degree between any two indices FZ_j and FZ_f of green decorative material R_i. Then, the overall order matrix is set up through pairwise comparison of indices to compute the order value of each index. On this basis, the indices of the green decorative material can be ranked. Let $a_i\beta_i$ be the preference threshold of green decorative material R_i. Then, the matrix of stochastic dominance degrees $RD_i=[rd_i(FZ_j,FZ_f)]_{M\times N}$ can be derived by:

$$rd_i(FZ_j, FZ_f) = \begin{cases} 1, r^j_{ih} = SD, \text{and } p_{ij} \geq p_{if} + \beta_i \\ \dfrac{p_{ij} - p_{if}}{\beta_i}, s^j_{if} = SD, \text{and } p_{if} < p_{ij} < p_{ij} + \beta_i \\ 0, Otherwise \end{cases} \tag{5}$$

β_i can be calculated by:

$$\beta_i = \frac{2}{m(m-1)} \sum_{j=1}^{m} \sum_{f=1 f \neq j}^{m} \xi^i_{jf} \ (m = 1,2,...,21;\ f = 1,2,..,21)$$
$$where, \xi^i_{jf} = \begin{cases} p_{ij} - p_{if}, p_{ij} \geq p_{if} \\ 0, p_{ij} < p_{if} \end{cases} \tag{6}$$

For $RD_i=[rd_i(FZ_j,FZ_f)]_{m\times m}$, the dominance of FZ_j over FZ_f is positively correlated with the value of $rd_i(FZ_j,FZ_f)$.

(2) Order value of each index

To compute the order value $\delta_i(FZ_j)$ for each index of each green decorative material, the first step is to calculate the outflow $\delta^+_i(FZ_j)$ and inflow $\delta^-_i(FZ_j)$ of index FZ_l of green decorative material R_i, based on the stochastic dominance matrix $RD_i=[rd_i(FZ_j,FZ_f)]_{m\times m}$. Note that $\delta^+_i(FZ_j)$ and $\delta^-_i(FZ_j)$ are the confidence of FZ_j being superior and inferior to the other index, respectively. The greater the $\delta^+_i(FZ_j)$, the smaller the $\delta^-_i(FZ_j)$, and the better the environmental functions of the material on the corresponding index. According to the matrix of stochastic dominance degree $RD_i=[rd_i(FZ_j,FZ_f)]_{m\times m}$, $\delta^+_i(FZ_j)$ and $\delta^-_i(FZ_j)$ can be respectively defined by:

$$\delta^+_i(FZ_j) = \sum_m rd(FZ_j, FZ_f) \tag{7}$$

$$\delta^-_i(FZ_j) = \sum_m rd(FZ_f, FZ_j) \tag{8}$$

According to $\delta^+_i(FZ_j)$ and $\delta^-_i(FZ_j)$, the order value $\delta_i(FZ_j)$ of each index of each green decorative material can be calculated by:

$$\delta_i(FZ_j) = \delta^+_i(FZ_j) - \delta^-_i(FZ_j) \tag{9}$$

The greater the order value $\delta_i(FZ_j)$, the better the environmental functions of the material on index FZ_j.

4. EVALUATION OF GREEN ENVIRONMENTAL FUNCTIONS

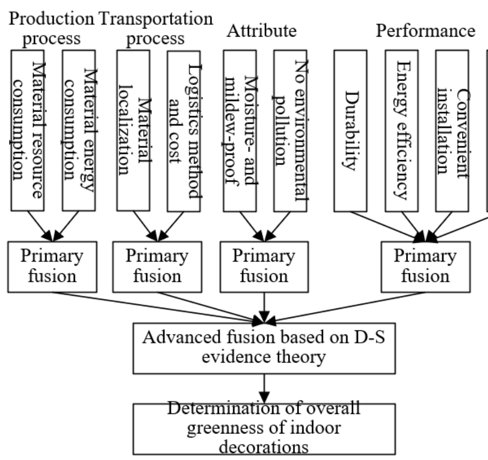

Figure 2. Flow of evaluation model

Various types of decorative materials are adopted for indoor design. To accurately evaluate the overall greenness of indoor decorations, it is necessary to integrate the evaluation information of environmental functions of each decorative material by a certain optimization rule, and further process the fused information. Considering the floating error of the relevant indices, as well as the weight difference between indices, this paper proposes an environmental function prediction algorithm for indoor decorations based on fuzzy D-S evidence theory. Then, the greenness of indoor design decorations was evaluated based on the index data acquired previously. Figure 2 shows the flow of the evaluation model for the greenness of indoor designs.

Relying on data intelligence algorithm, this paper processes the fused information on the environmental functions of different decorative materials. The index data of m green decorative materials at time h can be obtained from the definition of the optimal fuzzy set at time h. For this set, the environmental function information of green decorative materials R_i and R_j at time h is denoted as $E_i(h)$ and $E_j(h)$, respectively. The values of $E_i(h)$ and $E_j(h)$ are negatively correlated with the complexity of the fusion between index data of the two materials at time h.

To facilitate the analysis of the fusion complexity between index data, this paper introduces the fusion membership function $W_{ij}(h)\in[0, k]$, which can be generated through the mapping between $E_i(h)$ and $E_j(h)$. The value of membership function $W_{ij}(h)$ can be characterized by the degree of fusion between the index data of any two green decorative materials at time h. The membership function $W_{ij}(h)$ can be defined as:

$$W_{ij}(h)=exp\left\{-\frac{1}{2}\left|e_i(h)-e_j(h)\right|\right\} \tag{10}$$

The closer the $W_{ij}(h)$ value is to 1, the deeper the fusion between the index data of two green decorative materials; the closer the $W_{ij}(h)$ value is to 0, the shallower the fusion. Based on the degree of fusion, the data fusion matrix W can be established as:

$$W=\begin{bmatrix} 1 & W_{12}(h) & \cdots & W_{1n}(h) \\ W_{21}(h) & 1 & \cdots & W_{2n}(h) \\ \vdots & \vdots & \ddots & \ddots \\ W_{n1}(h) & W_{n2}(h) & \cdots & 1 \end{bmatrix} \tag{11}$$

If the sum of the elements in any row of matrix W is large, there is a small gap between $E_i(h)$ and the mean; if the sum is small, there is a large deviation of the index data on green decorative material R_i. The consistent fusion degree of the indices for material R_i can be expressed as:

$$\lambda_i(h)=\sum_{j=1}^{n}w_{ij}(h)/n \tag{12}$$

However, the mean consistent fusion degree calculated by formula (12) cannot reflect the stability of environmental functions of green decorative materials. If the index data on green decorative material R_i remain stable with the elapse of time, the fusion degree of the data will deviate greatly from that of the evaluation information of other green decorative materials, and exert a major impact on the uniform distribution of fusion degrees. The distribution balance of green decorative material R_i at time h can be expressed as:

$$\gamma_i(h)=1/\sum_{j=1}^{n}\left(v_i(h)-w_{ij}(h)^2\right)/n \tag{13}$$

During indoor design, preference should be given to green decorative materials with consistent, and uniformly distributed fusion degrees. The distribution and weight of fusion degree depend on the uniformity and fusion coefficient of green decorative materials. Hence, the fusion degree weights can be balanced with the uniform fusion degree coefficient and distribution balance coefficient. The weight coefficient of green decorative material R_i at time h can be calculated by:

$$\theta_i(h)=\lambda_i(h)\times\gamma_i(h) \tag{14}$$

The result of formula (14) can be normalized by:

$$\theta_i(h)=\Phi(h)/\sum_{i=1}^{n}\Phi_i(h) \tag{15}$$

The final fusion result can be given by:

$$\hat{a}=\sum_{i=1}^{n}\theta_i(h)e_i(h)=\sum_{i=1}^{n}\frac{\theta_i(h)e_i(h)}{\sum_{i=1}^{n}\theta_i(h)} \tag{16}$$

The D-S evidence theory can overcome the limits of prior probability and the corresponding conditional probability. By applying this theory to the evaluation of the overall greenness of multiple indoor green decorative materials, the environmental function information of these materials can be described through the reasoning and decision-making processes of D-S evidence.

The conflicting decisions are greatly affected by low-reliable evidence. To minimize the effect, this paper proposes a consistent fusion algorithm for the reliability of conflicting evidence, which excels in modification based on the consistency of original reliable evidence, and modification based on the consistency of combination rules. The proposed algorithm simultaneously enhances the evidence reliability of environmental function information on green decorative materials, and the accuracy of evidence fusion based on the information, reducing the influence of reliable evidence weighting on composite decision. Let n_1 and n_2 be the basic confidence distribution functions; X_i and Y_i be the focal elements. The basic probability distribution function can be expressed as:

$$\begin{aligned} &n(X)=0, X=\varphi \\ &n(X)=\frac{\sum_{X_iY_i=X}n_1(X_i)n_2(Y_j)}{1-\sum_{X_iY_i=\delta}n_1(X_i)n_2(Y_j)}, X=\varphi \end{aligned} \tag{17}$$

In the evaluation data fusion system, the global reliability of each evidence can be given by:

$$\lambda_l(Q_l)=\max_{1\le i\le n}\left(\lambda_i(Q_i)\right) \tag{18}$$

The weight evidence in the system, i.e., the most reliable evidence in the calculation results, is called the weight evidence λ_l of the fusion system. Each weight is assigned a weight referring to the global reliability of the evidence by:

$$\gamma_i=\frac{\lambda_i(Q_i)}{\lambda_l(Q_l)}=\frac{\lambda_i(Q_i)}{\max_{1\le i\le n}\lambda_i(Q_i)} \tag{19}$$

The basic reliability $RE_i(h)$ can be obtained through normalization:

$$RE_i(h) = \Phi_i(h) / \sum_{i=1}^{n} \Phi_i(h) \tag{20}$$

By reassigning the weight coefficients to evidence, the basic probability distribution function can be obtained as:

$$n_i(X_l) = \begin{cases} \gamma_i \bullet n_i(X_l) \\ 1 - \sum \gamma_i \bullet n_i(Y_l) \end{cases} \tag{21}$$

The new basic probability distribution function (21) can be fused by the following combination rules:

$$\begin{cases} n(\varsigma) = 0 \\ n(X) = \sum\limits_{\substack{X_l \cap Y_l = X \\ X_l \bullet Y_l \subseteq \Psi}} \tilde{n}_i(X_l) \bullet \tilde{n}_j(Y_l) + \sum\limits_{\substack{X_l \cap Y_l = \varphi \\ Y_l \subseteq \Psi}} \mu(X, Y_l) \end{cases} \tag{22}$$

With γ_i=1, a new mass function can be obtained as:

$$n_i(\tilde{X}_l) = \begin{cases} n_i(X_l) \\ 1 - \sum n_i(Y_l) \end{cases} \tag{23}$$

Substituting ten indices R_1-R_{10} (material resource consumption; material energy consumption; material localization; logistics method and cost; moisture- and mildew-proof; no environmental pollution; durability; energy efficiency; convenient installation; recyclability) into formula (23), the basic probability distribution function can be obtained as:

$$\tilde{n}(A) \begin{cases} n(\alpha_1) ... A = \alpha_1 \\ n(\alpha_2) ... A = \alpha_2 \\ n(\alpha_3) ... A = \alpha_3 \\ n(\alpha_4) ... A = \alpha_4 \\ n(\alpha_5) ... A = \alpha_5 \\ 1 - n(\alpha_1) - n(\alpha_2) - n(\alpha_3) - n(\alpha_4) - n(\alpha_5) ... A = \Psi \end{cases} \tag{24}$$

The consistency can be described as:

$$\mu(X, Y_l) = \frac{\tilde{n}_i(X_l)^3 \tilde{n}_j(X)}{\tilde{n}_i(X)^2 + \tilde{n}_j(Y_l)^2} + \frac{\tilde{n}_i(Y_l)^3 \tilde{n}_j(X)}{\tilde{n}_i(Y_l)^2 + \tilde{n}_j(X)^2} \tag{25}$$

Formula (25) shows that the proposed algorithm fully mines the information consistency between highly reliable evidence, and effectively solves the conflicts between environmental function information and evidence. In addition, each evidence is weighted through full consideration of the safety and reliability of evaluation information.

5. EXPERIMENTS AND RESULTS ANALYSIS

Table 1 lists the outflow, inflow, and order value of the environmental functions of green decorative materials. The order value δ is positively correlated with the environmental function level of the corresponding green decorative material on index FZ_j. Thus, the evaluation indices can be ranked by the order value.

Table 1. Outflow, inflow, and order value of each index

Index	FZ_1	FZ_2	FZ_3	FZ_4	FZ_5	FZ_6	FZ_7	FZ_8	FZ_9	FZ_{10}
δ^+	3.2564	1.625	0.824	6.321	-5.326	-6.251	-7.235	-3.625	-0.008	-9.254
δ^-	3.7856	1.652	0.852	6.233	-5.324	-6.258	-7.253	-3.625	-0.018	-9.254
δ	3.7584	1.625	0.825	6.235	-5.125	-6.352	-7.251	-3.256	-0.007	-9.021
Index	FZ'_1	FZ'_2	FZ'_3	FZ'_4	FZ'_5	FZ'_6	FZ'_7	FZ'_8	FZ'_9	FZ'_{10}
δ^+	-4.2525	-4.613	-3.825	-4.313	-3.324	-6.221	-8.215	4.614	4.034	2.2254
δ^-	-4.7836	-4.652	-8.824	-4.238	-5.334	-6.214	-4.248	3.652	4.035	2.285
δ	-3.7258	-4.614	-5.818	-4.259	-5.127	-6.319	-7.237	4.248	4.018	2.019

Table 2. Fused environmental function information of different green decorative materials

Index	FZ_1	FZ_2	FZ_3	FZ_4	FZ_5	FZ_6	FZ_7	FZ_8	FZ_9	FZ_{10}
Material 1	0.685	0.658	0.594	0.623	0.584	0.625	0.594	0.612	0.572	0.615
Material 2	0.724	0.602	0.715	0.630	0.185	0.802	0.736	0.632	0.285	0.826
Result	0.785	0.652	0.534	0.032	0.745	0.716	0.685	0.695	0.623	0.258
Index	FZ'_1	FZ'_2	FZ'_3	FZ'_4	FZ'_5	FZ'_6	FZ'_7	FZ'_8	FZ'_9	FZ'_{10}
Material 1	0.625	0.658	0.524	0.613	0.564	0.525	0.614	0.635	0.537	0.524
Material 2	0.714	0.637	0.712	0.627	0.143	0.826	0.748	0.615	0.238	0.827
Result	0.736	0.637	0.548	0.048	0.772	0.728	0.638	0.649	0.638	0.273

Table 3. Coating transmittance at different first pulling rates

	Blank glass	1.0	2.0	3.0	4.0	5.0
Maximum	91.35	85.27	79.26	82.15	78.62	79.28
Minimum	88.21	82.16	80.26	76.29	73.26	69.28
Mean	90.25	83.26	82.29	79.29	77.26	75.29
Standard deviation	0.82	0.46	0.85	1.62	1.79	2.95

Table 2 shows the fused environmental function information of different green decorative materials. Materials 1 and 2 were unqualified in terms of production process, and qualified on the other aspects. Before the experiments, an expert survey was carried out. The results indicate that the environmental functions of both materials are unqualified. Thus, the results of our algorithm are inconsistent with the results of expert survey. The proposed evaluation model achieved an accuracy of 97% in the environmental function evaluation of green decorative materials. This is of certain practical significance, as it meets the application standard for household-based indoor design.

The high performance of the prepared super-hydrophobic and oleophobic coating was verified through contrastive experiments. Tables 3 and 4 present the coating transmittance at different first and second pulling rates. The pulling rate was set to 1.0cm/s, 2.0cm/s, 3.0cm/s, 4.0cm/s, and 5.0cm/s, in turn. As shown in Table 3, the transmittance of the flat coating gradually decreased with the growth of first pulling rate. When the first pulling rate was below 2.0cm/s, the mean transmittance of the prepared coating was above 0.8 in the range of visible light wavelengths; When the first pulling rate was above 2.0cm/s, the mean transmittance of the prepared coating was smaller than 0.8 in the range of visible light wavelengths. Hence, the transmittance of the super-hydrophobic and oleophobic coating is superior at a low first pulling rate.

As shown in Table 4, within the range of visible light wavelengths, the coating transmittance did not fluctuate significantly, as the second pulling rate changed from 1.0cm/s, 2.0cm/s, 3.0cm/s, 4.0cm/s, to 5.0cm/s. In the short wavelength range, the transmittance quickly declined until 0. Besides, the mean transmittance did not drop significantly, with the growth of second pulling rate, and the standard deviation remained small. Therefore, the transmittance of the prepared super-hydrophobic and oleophobic coating is not greatly affected by second pulling rate. Figure 3 shows the composite performance of the prepared coating. Obviously, our coating achieved the best overall performance at the second pulling rate of 1.0cm/s.

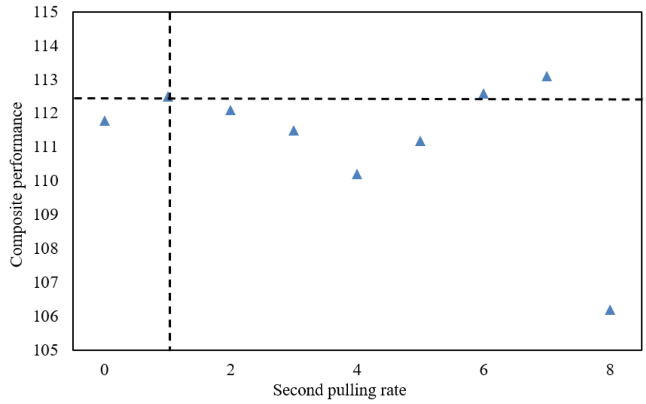

Figure 3. Composite performance of the prepared coating

The super-hydrophobic and oleophobic coating was prepared with nontoxic or low-toxic solvents. Table 5 shows the physical properties of the coating prepared from aminopropylene resin. Before second pulling, the suspension was prepared with four solvents: isopropanol, n-ethane, acetone, and valinone. The coating prepared with the first three solvents were not super-hydrophobic, while that prepared with isopropanol and acetone was both hydrophobic and oleophobic; that prepared with valinone was the only coating realizing super-hydrophobicity and oleophobicity, but the transmittance of the coating was merely 80.59%. Table 6 shows the physical properties of the coating prepared from polysiloxane resin. Before second pulling, the suspension was prepared with four solvents: isopropanol, n-ethane, acetone, and valinone. The coatings prepared with all four solvents achieved super-hydrophobicity and oleophobicity. The transmittance of the coating prepared with acetone was only 67.9%, while that of the coating prepared with any of the other solvents surpassed 85%.

Table 4. Coating transmittance at different second pulling rates

	Blank glass	1.0	2.0	3.0	4.0	5.0
Maximum	92.36	89.23	77.29	83.17	79.64	77.25
Minimum	89.24	86.15	81.24	78.25	74.24	73.26
Mean	92.37	87.25	88.25	77.32	79.24	72.25
Standard deviation	0.85	0.49	0.82	1.66	1.73	2.97

Table 5. Physical properties of the coating prepared from aminopropylene resin

	Isopropanol	n-ethane	Acetone	Valinone
Water contact Angle (%)	142.8	125.3	138.5	155.8
Oil contact Angle (%)	105.6	80.3	102.5	108.4
Transmittance (%)	58.6	85.2	85.9	80.59
Fog degree (%)	92.35	48.25	82.16	85.29
Adhesion (%)	100	101	100	101

Table 6. Physical properties of the coating prepared from polysiloxane resin

	Isopropanol	n-ethane	Acetone	Valinone
Water contact Angle (%)	153.6	127.4	135.7	156.6
Oil contact Angle (%)	106.4	81.5	103.4	109.6
Transmittance (%)	67.9	86.4	86.7	85.54
Fog degree (%)	93.38	47.24	81.15	87.27
Adhesion (%)	101	100	100	100

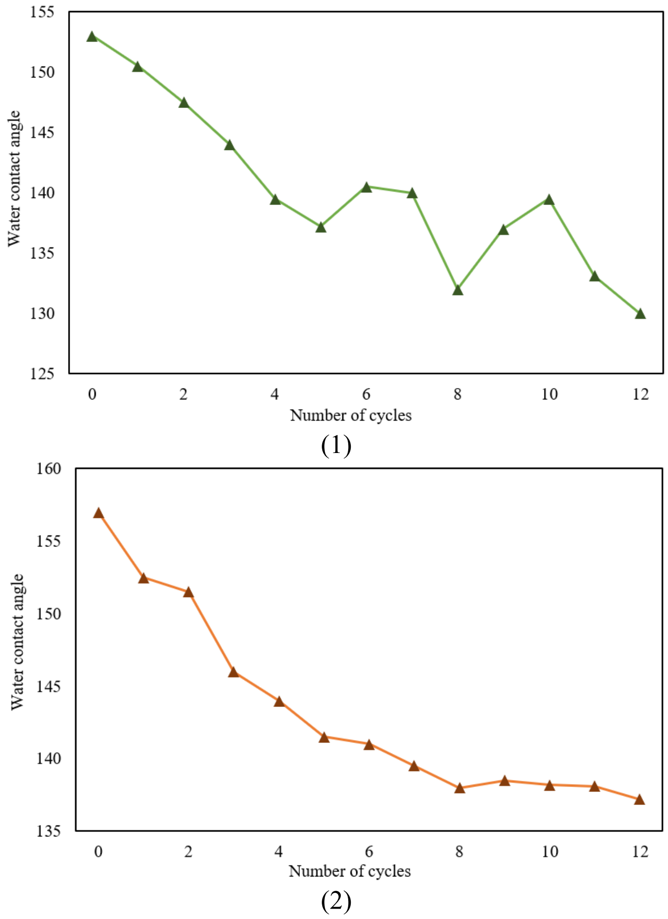

Figure 4. Wear resistance of the prepared coating

Figure 4 shows the test results on the wear resistance of the coatings prepared with aminopropylene resin and polysiloxane resin. The wear resistance test was carried out in the following steps: Place the super-hydrophobic and oleophobic coating sample with an additional 80g weight evenly on a piece of sandpaper, and make the sample move forward at uniform speed by 15cm against the friction of the sandpaper. Four flips of the sample were treated as a cycle. Figure 4 shows the change of water contact angle of the sample after each cycle. It can be seen that the water contact angle of the two coatings both reduced with the growing number of cycles. After 8 cycles, the water contact angle of the coating prepared with polysiloxane resin gradually stabilized, while that of the coating prepared with aminopropylene resin fluctuated. This means the coating prepared with polysiloxane resin is relatively stable and good in performance.

6. CONCLUSIONS

This paper evaluates the environmental function and explores the preparation method of green decorative materials in indoor design. Firstly, the authors explained the types and purchase principles of green decorative materials, and clarified the preparation flow of wood product coating for green decorative materials in indoor design. Then, an evaluation model was established for the environmental functions of green decorative materials, and a prediction algorithm was developed for the environmental function of indoor decorations based on fuzzy D-S evidence theory, laying the basis for evaluating the greenness of decorative materials in indoor design. Through experiments, the fused environmental protection information was obtained for different green decorative materials, which demonstrates the effectiveness of our evaluation method. Further, the coating transmittance was counted at different first and second pulling rates, and the composite performance of the coatings was plotted. It was concluded that the super-hydrophobic and oleophobic coatings have a relatively good transmittance at a low first pulling rate, and their transmittance is not greatly affected by second pulling rate. Finally, the physical properties and wear resistance of the prepared super-hydrophobic and oleophobic coatings were tested. The test results confirm the superior performance of the prepared coatings.

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