Dual-Functional Porous Wood Filter for Simultaneous Oil/Water Separation and Organic Pollutant Removal

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ABSTRACT: High-performance functional materials capable of simultaneously separating oil from water and removing water-soluble contaminants are critically demanded for wastewater treatment but remain highly challenging. Wood, a naturally occurring porous material composed of numerous open microchannels along the growth direction, may serve as a desirable scaffold for the development of efficient filtration materials for water treatment. Herein, by in situ deposition of silver nanoparticles (Ag NPs) within the channels of balsa wood, we developed dual-functional Ag/wood filters for simultaneous oil/water separation and organic dye removal from water in a one-step process. Owing to their superhydrophilicity and underwater superoleophobicity, the as-prepared Ag/wood filters can selectively separate water from oil with a high efficiency (~99%). Moreover, benefiting from the catalytic activity of Ag NPs anchored to the surface of the wood channels, the Ag/wood filters effectively removed methylene blue (MB) from water during the oil/water separation process; the MB removal efficiency was highly dependent on the thickness of the wood filters. Specifically, the gravity-driven separation using a 6 mm-thick Ag/wood filter showed a high MB degradation efficiency of 94.03% and a water flux of 2600 L·m⁻²·h⁻¹. The proposed wood-based filtration material features renewable, inexpensive raw materials, facile processing, and scale-up potential. Such dual-functional Ag/wood filters capable of rapid and efficient removal of insoluble oils and soluble pollutants from water in a one-step process offer a promising solution for wastewater treatment.

INTRODUCTION

The extensive release of organic contaminants (e.g., oils, aromatic compounds, and dyes) from the chemical industry has currently been a major source of water pollution, causing harmful impacts on the environment and human health.¹–³ A variety of approaches, such as gravity separation, centrifugation, chemical oxidation, photocatalytic degradation, physical adsorption, and membrane filtration, have been widely developed for the removal of organic contaminants. Among these methods, membrane filtration is considered to be one of the most promising approaches for water purification because of its easy operation, high efficiency, and relatively low cost.⁴–⁶ Various porous filtration materials with special wetting properties such as metallic meshes⁷–¹⁰ and polymeric membranes¹¹–¹³ have been developed for efficient wastewater treatment. Despite their high flux rates and high separation efficiencies, the filtration materials based on metals and synthetic polymers still have several drawbacks, which severely restrict their large-scale applications, such as high material costs, low corrosion resistance, poor degradability, and disposal issues.¹⁴ In most cases, filtration membranes based solely on the special wettability of materials cannot remove water-soluble contaminants (e.g., organic dyes). Therefore, it is of great importance to develop simple, low-cost, eco-friendly, and easily scalable methods for effectively removing organic contaminants (including both insoluble oils and soluble dyes) from water, ideally based on renewable resources.
Wood is a widely used natural material with a highly porous 3D hierarchical structure composed of numerous aligned hollow fibers along its growth direction. The living tree has evolved specialized xylem tissues (tracheids in softwood and vessels in hardwood) for transporting water from the roots to the leaves. The well-aligned microchannels make wood xylem an ideal scaffold for liquid transport. Recently, taking advantage of its natural hydrophilicity and porous structure, cross sections of natural spruce wood were directly utilized as filtration membranes for oil/water separation. The anisotropic microchannel network facilitates rapid water transport, and the hydrophilic nature of the cell wall components (cellulose and hemicelluloses) renders the wood cross sections and the hydrophilic nature of the cell wall components superhydrophilic and underwater superoleophobic properties, thus allowing only water to pass through while blocking oils and resulting in a selective separation. The large-lumen vessels in balsa wood provided high-speed channels for water transport, and the incorporated Ag NPs anchored to the surface of the wood channels functioned as catalytic sites for the degradation of methylene blue (MB) in the flowing water solution. With the synergistic effects of the hydrophilicity of the porous wood structure and the catalytic activity of Ag NPs, both insoluble oils and soluble MB were effectively removed from an aqueous solution in a one-step process. Such dual-functional Ag/wood filters offer a scalable and cost-effective strategy for rapid and efficient wastewater treatment.

RESULTS AND DISCUSSION

The synthesis of Ag/wood composite filters for efficient oil/water separation and organic dye removal is schematically illustrated in Scheme 1. Wood provides a highly porous structure of hollow fibers with cell walls mainly consisting of stiff cellulose microfibrils embedded in a soft amorphous matrix of hemicelluloses and lignin. Once the wood slices are immersed in the Ag(NH$_3$)$_2$NO$_3$ precursor solution with the assistance of vacuum, Ag(NH$_3$)$_2$$^+$ ions are expected to infiltrate into the porous cell walls, enabling the uniform distribution of metal complex ions within the wood matrix. Upon heating the impregnated wood slices in the solution, lignin can reduce Ag(NH$_3$)$_2$$^+$ ions in situ to metallic Ag NPs that are eventually anchored to the surface of the wood channels. Because of the mesoporous structure of balsa wood with numerous elongated vessel channels that are decorated with the catalytic Ag NPs, the resulting Ag/wood filter exhibited fascinating dual functionalities of simultaneous oil/water separation and organic dye removal, enabling one-step treatment of wastewater containing both water-insoluble oils and soluble organic pollutants.

Morphology and Structure. The appearance and microstructure of the as-prepared Ag/wood filters are presented in Figure 1. The Ag/wood filter became dark in contrast with the natural yellowish wood due to the plasmonic effect of the metal Ag NPs in situ deposited inside the wood matrix (Figure 1a). Cleavage of the sample through its center reveals a uniform dark color from the inside out, indicating the homogeneous distribution of Ag NPs within the wood structure (Figure S1). Inductively coupled plasma mass spectrometry (ICP-MS) analysis indicated a 4.78 wt % content of Ag NPs in the obtained Ag/wood filter. It is worth noting that lignin in the cell walls contains many functional groups (e.g., hydroxyl, carbonyl, and aldehyde groups), which can function as reducing agents for in situ synthesis of Ag NPs in the wood matrix. The 3D interpenetrating lignin network could also

Scheme 1. Schematic Illustration of the Fabrication of Dual-Functional Ag/Wood Filters for Simultaneous Oil/Water Separation and Organic Pollutant Removal
serve as a stabilizing agent to anchor Ag NPs in the wood structure. The unique 3D porous structure of natural wood was well preserved in the Ag/wood filter after decoration with Ag NPs, and numerous honeycomb-like fiber tracheids and large-lumen vessels can be observed (Figure 1b). The fiber tracheids with smaller lumen diameters (50–60 μm) are mainly responsible for structural support, while vessels with larger lumen diameters (150–200 μm) function as the main liquid transport pathways. The magnified SEM image clearly shows aligned and open vessel channels that are connected via perforation plates at the cell ends, extending through the entire wood thickness (highlighted with yellow dashed lines, Figure 1c). The continuous vessel channels allowed the precursor solution to deeply infiltrate the wood structure, enabling the in situ deposition of Ag NPs within the wood scaffold. The presence of Ag NPs within vessel channels was confirmed by the energy-dispersive X-ray (EDX) maps (Figure 1d) in which elemental Ag was homogeneously distributed on the channel surfaces. The Ag NP-decorated vessel lumens can serve as ideal catalytic reaction microchannels for water purification.

The specific morphology and particle size of the in situ synthesized Ag NPs were determined by transmission electron microscopy (TEM) (Figure 2a). The Ag NPs were roughly spherically shaped with a size range of 5–20 nm, as summarized in the inset chart. The porous wood scaffold can serve as an ideal support to prevent the agglomeration of Ag NPs. The crystalline structure of Ag NPs was further analyzed by high-resolution TEM (HRTEM) (Figure 2b). The measured lattice fringe spacing was approximately 0.23 nm, corresponding to the (111) plane of the face-centered-cubic Ag crystal. The selective area electronic diffraction (SAED) pattern also confirmed the high crystallinity of Ag NPs (inset in Figure 2b). X-ray powder diffraction (XRD) measurements were performed to identify the crystal structure of the as-prepared Ag/wood filters. As shown in Figure 2c, the XRD pattern of the Ag/wood composite clearly displays characteristic diffraction peaks at 38.1° (111), 44.3° (200), 64.4° (220), and 77.7° (311), which can be well indexed to the formed face-centered-cubic structure of Ag (JCPDS 4-783). These peaks indicate that the precursor Ag ions were completely reduced to metal Ag in the wood matrix. The average Ag NP crystal size was calculated to be 16.5 nm from the Ag (111) peak width using the Scherrer formula, in agreement with the TEM results. The formation of Ag NPs within the Ag/wood filter was further verified by X-ray photoelectron spectroscopy (XPS) (Figure 2d). The Ag 3d peak revealed the presence of zero-valent Ag with two main components at 368.7 eV (Ag0 3d5/2) and 374.7 eV (Ag0 3d3/2), corresponding to the Ag NPs.  

**Oil/Water Separation.** To demonstrate the potential of the Ag-decorated wood cross sections for effective oil/water separation, the wettability of the as-prepared Ag/wood filter (6
mm in thickness) was tested by measuring the contact angles (CAs) of water and oil droplets. As shown in Figure S2, when a water droplet was placed on the wood surface, it quickly spread out and penetrated into the wood capillaries with a water CA of \( \sim 0^\circ \), indicating a superhydrophilic surface of the wood filter. In contrast, both light (olive oil) and heavy (dichloromethane) oil droplets remained on the underwater wood surface with a high CA, showing a negligible affinity between the surface and oils (Figure 3a). The water-soaked wood filter exhibited high oil CAs exceeding \( 150^\circ \) for various oils (Figure 3b), suggesting an underwater oil-repellent behavior. The underwater superoleophobicity is the result of a stable wood/water/oil three-phase system. Wood is known to be hygroscopic because of its hydrophilic cell wall components (cellulose and hemicelluloses). When the wood filter is prewetted with water, water can enter the porous wood structure by penetrating the cell walls and filling up the cell lumina, which forms a water film on the wood surface.\(^{19}\) As a result, the water film prevents the oil droplets from contacting the wood surface, thus endowing the

Figure 3. Wetting properties and oil/water separation efficiency of the Ag/wood filters. (a) Photographs of olive oil and dichloromethane droplets sitting on the water-soaked wood filter with high contact angles. (b) Contact angles of Ag/wood filters for various oils demonstrating their underwater superoleophobicity. (c) Photographs of the oil/water separation process in which water flowed through the wood filter, while the oil phase (dyed red) was retained on top. (e) Separation efficiency of the Ag/wood filter for various oils.

Figure 4. Removal of water-soluble MB from water using the Ag/wood filters. (a) Experimental setup for the MB removal test and photographs of the resulting filtrates treated with the corresponding Ag/wood filters with different thicknesses. (b) UV–vis spectra of the MB solution before and after filtration using the Ag/wood filters with different thicknesses. (c) MB degradation efficiency and water flux rate as a function of filter thickness. (d) Degradation efficiency at different MB concentrations.
surface with excellent underwater superoleophobicity without the need for chemical pretreatment to lower its surface energy.

The separation of oil/water mixtures was carried out by directly pouring the mixtures (50% v/v) onto the wetted Ag/wood filters, which were fixed between two glass tubes held by a clamp (Figure 3c). During the separation process, water (dyed blue) quickly flowed through the wood filter into the underlaying flask with a high flux (2600 L m⁻² h⁻¹), while the oil phase (dyed red) was blocked and retained on top of the filter because of the underwater superoleophobicity of the wood material. The separation was driven only by gravity without external pressure applied. Clearly, no traces of oil were visible in the collected filtrate, which was also quantitatively analyzed using an infrared spectrometer oil content analyzer. The separation efficiency was characterized by analyzing the oil content before and after separation. As shown in Figure 3d, various oil phases, including toluene, motor oil, olive oil, and n-hexane, can be separated from the oil/water mixtures with a high separation efficiency (∼99%). Of course, the water flow rate was highly dependent on the thickness of the filter, and thinner filters had significantly higher water fluxes (e.g., a 2 mm-thick wood filter displayed a flux of 14,870 L m⁻² h⁻¹).

However, in view of the simultaneous catalytic degradation of MB in the flowing water solution (see the next section for more details), an optimal 6 mm-thick wood filter was selected for oil/water separation with a flux of 2600 L m⁻² h⁻¹. In general, various woods including softwoods and hardwoods can serve as water-removing materials for oil/water separation given their similar hydrophilicity and porous structures. hardwoods seem to be better candidates for efficient water transport due to the presence of large vessel channels, in contrast with softwoods that mainly rely on pits connecting the tapered ends of tracheids for continuous water transport.16

**Removal of Water-Soluble Dye.** Taking advantage of the well-aligned microstructure of wood as well as the catalytic Ag NPs anchored to the cell walls, the as-prepared Ag/wood filters can be used for efficient removal of organic pollutants from water. MB was selected as a model pollutant to test the removal efficiency of the wood-derived filters. Figure 4a shows the filtration setup for organic pollutant removal. The blue color of the MB/NaBH₄ aqueous solution (10 mg L⁻¹) faded after flowing through the Ag/wood filters, indicating efficient removal of MB. The MB removal efficiency was highly dependent on the filter thickness, with thicker wood filters (6 and 8 mm) generating clear filtrates, in contrast to the partial solution discoloration when using the thinner ones (2 and 4 mm). The degradation ability of the Ag/wood filters toward MB was further confirmed by the UV−vis spectra of the MB/NaBH₄ solutions before and after filtration (Figure 4b). The characteristic absorbance peak for MB at 664 nm notably weakened after the solution was treated with the Ag/wood filter, and the MB removal efficiency increased with the filter thickness, which is in line with the color changes of the solutions. Specifically, the thicker wood filters (6 and 8 mm) displayed relatively high MB removal efficiencies over 94.0%. For reference, when the MB solution without NaBH₄ was flowed through the Ag/wood filter, only slight changes in the solution color and UV−vis spectra were detected (Figure S3). This indicates that the physical adsorption of MB by the wood matrix plays a minor role, and the high MB removal efficiency was mainly attributed to the catalytic degradation of MB by the Ag NPs anchored to the surface of the wood channels. The Ag NPs serve as efficient electron relays between nucleophilic NaBH₄ and electrophilic MB to overcome the kinetic barrier for the catalytic reduction of MB.33−36

Concerning the efficiency of the Ag/wood filter for water treatment, both the MB removal efficiency and water flux rate should be taken into account. We also investigated the gravity-driven water flux of the Ag/wood filters as a function of thickness. It should be noted that the loading of Ag NPs hardly influenced the water flux in the wood filters, indicating that the porous structure of wood was well maintained after decoration with Ag NPs without blocking the vessel channels (Figure S4). As shown in Figure 4c, the 2 mm-thick wood filter provided a high water flux of 14,870 L m⁻² h⁻¹ due to its open and well-aligned wood channels, but this came at the expense of a lower MB degradation efficiency of only 45%. An increase in the thickness of wood filters resulted in a remarkably lower water flux (e.g., the 8 mm-thick wood filter gives a water flux of only 1100 L m⁻² h⁻¹). Although the thicker wood filter was not beneficial for fast liquid transport, the elongated wood channels and perforation plates connecting the vessel channels facilitated sufficient contact between the catalytic Ag NPs and the MB solution, thus enabling the highly efficient catalytic degradation of MB in water. Taking both factors into account, the 6 mm-thick wood filter showed the most desirable performance with a high MB degradation efficiency of 94.03% and a water flux of 2600 L m⁻² h⁻¹. The Ag/wood filter maintained a high degradation efficiency above 90% until the MB concentration reached 20 mg L⁻¹ above which the degradation efficiency began to slowly decrease (Figure 4d). Moreover, the MB degradation efficiency remained nearly constant over a broad pH range (Figure S5). The leachability of the anchored Ag NPs within the Ag/wood filters was also investigated using ICP-MS to measure the Ag content in the filtrate after water treatment. The results showed that the Ag content in the filtrate was as low as 0.008 ppm after an MB solution (3 L) was flowed through the wood filters, confirming the good stability of the Ag/wood filters. In addition, the 6 mm-thick Ag/wood filter retained an MB degradation efficiency of ∼90% after five filtration−rinsing cycles, indicating good reusability of the wood filter for water purification (Figure S6).

The promising water treatment performance of the Ag/wood filters originates from the hydrophilic and highly porous 3D structure of the wood scaffold, which provides open and well-aligned channels for efficient water transport. Specifically, the balsa wood used to prepare the Ag/wood filters contains vessels with large lumina that function as the main pathways for water transport, while the smaller fiber tracheids surrounding the vessels are mainly responsible for structural support. Hence, the water transport performance of the Ag/wood filter is mainly determined by the vessel network, and the fiber tracheids interconnected via pits may play a minor role in water conduction.57 To verify this hypothesis, a dyeing solution of MB was flowed into the wood filter to visualize water flow pathways within the wood tissues by optical microscopy. For easy observation, natural wood was used instead of the dark-colored Ag/wood filter since they have similar internal microstructures. From the cross-sectional view in Figure 5a, it can be observed that the dyeing was mostly confined to the vessels that were randomly distributed on the wood surface. The wood filter was cut along the longitudinal direction to visualize the internal distribution of dye. As shown in Figure 5b, the elongated vessels running across the entire wood structure were selectively dyed blue, while most of fiber
tracheids remained undyed, except those close to the wood surface. The visual observations confirm that the vessels connected by the perforation plates were the principal channels for water transport, and the fiber tracheids were essentially not involved in fluid transport during filtration. The magnified image of a vessel in Figure 5c clearly shows that the perforation plate connecting the adjacent vessel elements was heavily dyed. Due to their micrometer-sized pores, the perforation plates may be regarded as the bottleneck for high-speed water transport along the vessel channel, which could explain the lower water flux in the thicker wood filters. A schematic of the degradation process of the organic pollutant in the vessel channel of the Ag/wood filter is shown in Figure 5d. The rapid and highly efficient degradation of MB in water can be ascribed to three factors. First, the uniformly distributed Ag NPs on the surface of the aligned vessel channels act as active sites for the catalytic reduction of MB. Secondly, the elongated channels as well as the perforation plates and pits in the vessel walls ensured sufficient contact between the Ag NPs and the organic pollutant. Finally, the open and well-aligned vessel channels with favorable hydrophilicity enabled the rapid transport of polluted water within the wood filters without significantly sacrificing the MB removal efficiency.

The 6 mm-thick Ag/wood filter was selected to demonstrate its capacity for simultaneously separating oil/water mixtures and removing soluble dyes from water using the homemade filtration setup. As shown in Video S1, when an oil/water mixture of n-hexane and MB/NaBH₄ aqueous solution (50% v/v) was poured into the upper tube, n-hexane (dyed red) was blocked and remained on top of the wood filter; meanwhile, the MB aqueous solution passed through the wood filter with colorless clean water eventually produced after filtration. It should be noted that the filtration process was driven only by gravity with no applied external pressure. Although separation materials based on metals and synthetic polymers have been developed for the simultaneous removal of both types of pollutants simultaneously from wastewater, their fabrication processes typically involve costly raw materials and complex procedures, thus restricting their large-scale applications. 38−40 In this work, the dual-functional Ag/wood filters based on the highly abundant, readily available, and renewable wood materials offer a cost-effective and scalable strategy for efficient wastewater treatment.

**CONCLUSIONS**

In summary, we have demonstrated a facile method for the fabrication of dual-functional Ag/wood filters for simultaneous oil/water separation and organic dye removal from water by the in situ deposition of Ag NPs in mesoporous balsa wood. The large-lumen vessels in the Ag/wood filter provided high-speed channels for water transport, and the incorporated Ag NPs anchored to the surface of the wood channels functioned as catalytic sites for the degradation of MB in water. Once the oil/water mixture was flowed through the Ag/wood filter, the oil phase was selectively blocked due to the superhydrophilic and underwater superoleophobic properties of wood; meanwhile, water-soluble MB was effectively removed as the water solution passed through the elongated vessel channels decorated with catalytic Ag NPs. Specifically, the gravity-driven separation using a 6 mm-thick Ag/wood filter exhibited a high separation efficiency (~99%) for various oil/water mixtures and a high MB removal efficiency (~94.0%) with a water flux of 2600 L·m⁻²·h⁻¹. Such dual-functional Ag/wood filters enable one-step treatment of wastewater containing both water-insoluble oils and water-soluble organic pollutants, providing a promising solution for water purification. The natural wood-derived filtration materials are cost-effective, biodegradable, and scalable and display great potential for practical applications in wastewater treatment.

**EXPERIMENTAL SECTION**

**Materials and Chemicals.** Balsa wood (Ochroma pyramidale) sapwood was cut into samples with the dimensions of 20 mm × 20 mm (radial × tangential) with various thicknesses (2, 4, 6 and 8 mm). Silver nitrate (AgNO₃), ammonium hydroxide (NH₄OH), methylene blue (MB), and sodium borohydride (NaBH₄) were purchased from Aladdin Chemistry Co. Ltd. (Shanghai, China). Toluene and n-hexane were obtained from Beijing Chemical Works (Beijing, China). Motor oil and olive oil were purchased from local stores. All of the chemicals were used as received without further purification. Deionized (DI) water was used throughout the experiments.

**Preparation of Ag/Wood Filter.** The Ag/wood filter was prepared by in situ growth of Ag NPs in the mesoporous wood structure in accordance with a previously reported procedure. 29 Briefly, a precursor Ag(NH₃)₂NO₃ solution was prepared by the dropwise addition of aqueous ammonia (NH₄OH, 10 wt %) into an aqueous AgNO₃ solution (0.02 M) until the solution turned clear. Wood slices were immersed in the Ag(NH₃)₂NO₃ solution for 30 min under 25 mmHg vacuum at room temperature. The mixed solution containing the wood slices was then heated at 80 °C for 12 h to facilitate the in situ deposition of Ag NPs in the wood matrix. Finally, the wood slices were removed from the solution and rinsed with DI water to obtain Ag/wood filters with an Ag NP content of 4.78 wt %. The Ag/wood filter samples with different thicknesses were denoted as Ag/wood-2, Ag/wood-4, Ag/wood-6, and Ag/wood-8.

**Oil/Water Separation Experiment.** Ag/wood filters were first immersed in water until they were fully hydrated before being mounted in a homemade filtration setup for oil/water separation. The wetted Ag/wood filters were fixed between

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**Figure 5.** Water transport pathways within the wood filter. Light microscopy images of a (a) cross section and (b) longitudinal section of the wood filter after filtration with a dying solution of MB. The elongated vessel channels were preferentially dyed, demonstrating their primary role in water transport. (c) Magnified image of a vessel channel showing the heavily dyed perforation plate. (d) Schematic illustration of the catalytic degradation of MB in a vessel channel anchored with Ag NPs.
two glass tubes held by a clamp. Oil/water mixtures (50% v/v) were poured into the upper tube, allowing only water to flow through the wood filter. The separation was driven only by gravity without an externally applied pressure. The oil content in the collected filtrate was measured using an infrared spectrometer oil content analyzer (Oil 480, Beijing Chinalvent Instrument Tech. Co. Ltd., China). The separation efficiency was calculated using the following equation:

\[
\text{separation efficiency (\%) } = 100 \times \frac{C_0 - C}{C_0}
\]

where \(C_0\) and \(C\) are the oil concentrations in the initial oil/water mixture and after filtration, respectively.

**Removal of MB from Water.** The catalytic degradation of MB in the presence of NaBH\(_4\) was performed to examine the water treatment performance of the Ag/wood filters. Typically, a NaBH\(_4\) aqueous solution (50 mM) was mixed with an aqueous solution of MB (10 mg·L\(^{-1}\)) for filtration. Ag/wood filters with different thicknesses were mounted in the abovementioned filtration setup, and the mixture solution was then filtered through the Ag/wood filters using only gravity. The water flux was determined by recording the amount of water flowing through the filter per unit time. A UV–vis spectrophotometer (Cary 5000, USA) was used to monitor the catalytic reactions and to obtain the UV–vis absorption spectra within a wavelength range of 500–800 nm. The MB concentration in the aqueous solution was determined by measuring the absorbance at 664 nm, and the MB degradation efficiency was calculated using the following equation:

\[
\text{degradation efficiency (\%) } = 100 \times \frac{C_1 - C_2}{C_1}
\]

where \(C_1\) and \(C_2\) are the MB concentrations in the initial aqueous solution and after filtration, respectively.

**Characterization.** The surface morphology and structure of samples were examined by field emission scanning electron microscopy (Hitachi SU-8010, Tokyo, Japan) equipped with an EDX spectrometer for elemental mapping. The morphology of the Ag NPs within the wood filters was characterized by TEM (JEM-1200EX) and HRTEM (FEI Tecnai G2 F20, FEI). The XRD patterns of samples were recorded using a Bruker D8 Advance diffractometer with Cu K\(\alpha\) radiation (\(\lambda = 1.541 \) Å) in the scanning angle (2\(\theta\)) range of 10 to 90°. The XPS spectra were recorded on a Thermo ESCALAB 250Xi spectrometer (Thermo Scientific, USA) using a monochromatic Al K\(\alpha\) X-ray source. The Ag content of the prepared Ag/wood filters was determined by ICP-MS (Agilent 7500ce). Underwater oil contact angles of the Ag/wood filters were measured by a contact angle meter (JC2000D, Shanghai Zhongchen Power-each Company, China) at room temperature.

**ASSOCIATED CONTENT**

1. **Supporting Information**
   
   The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acsomega.0c01606.

   Photographs of the inside of the Ag/wood filter and wetting properties of the wood surface in air; UV–vis spectra of the MB solution (without NaBH\(_4\)) before and after flowing through the Ag/wood filter; flux rates of the MB solutions flowing through the natural wood and Ag/wood filter; and MB degradation efficiency of the Ag/wood filter at different pH values of the solutions (PDF)

   Video S1, simultaneous separation of oil/water mixtures and removal of MB from water using the homemade filtration setup (AVI)

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**Notes**

The authors declare no competing financial interest.

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