Applications of Kapok Fiber

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Photocatalytic Kapok fiber is recognized as one of the most resilient and effective material sources accessible for environmental rehabilitation and energy production due to its exceptional photocatalytic performance, hollow structure, great renewability, and compressibility. There are, however, few detailed reviews on this matter with strong photocatalytic activity. Therefore, the most recent explosive advancement in photocatalytic kapok fiber, including various kapok fiber materials and overall fabrication methodologies, was examined to evaluate this advanced research. Pollutant absorption, photocatalytic degradation, hydrogen production, and CO_2 reduction were the main applications of this photocatalytic Kapok fiber.

kapok fiber hydrogen production adsorption degradation

1. Photocatalytic Hydrogen Production

Compared to various organic fuels, hydrogen is designated as a sustainable solar energy source, with a thermal efficiency of 120–142 MJ kg^{-1}. Currently, the global generation of hydrogen exceeds 44.5 million tons [1], and it will be the primary generator of power until 2080 [2]. However, there are numerous methods for producing hydrogen-like substances, and the most common is thermolysis [3], electrolysis [4], biomass [5], photolysis [4], and hydrolysis [6][7][8][9]. Photocatalytic water dissociation is a successful technology that has received a lot of interest due to its broad application for power and sustainability purposes. Artificial photosynthesis is one of the only sustainable, long-term answers to the forthcoming fuel and environmental crises [10]. A group of scientists has already investigated several photocatalyst substances [11]. Nevertheless, the majority of photocatalysts respond to ultraviolet (UV) light, which accounts for only 5% of solar energies [12]. TiO_2 has been intensively investigated as a prospective option for hydrogen production due to its acclaimed physical and chemical qualities, high permanence, earth-abundant, low cost, and non-toxicity. However, its large bandgap (3.0–3.2 eV) limits its absorptivity range [13]. Furthermore, graphitic carbon nitride (g-C_3N_4) has received a great deal of attention due to its physical and chemical characteristics, low cost, earth-abundant, simple preparation, renewability, and, most importantly, visible light responsiveness due to a narrow bandgap of 2.7 eV [14][15][16]. However, the photocatalytic performance is limited by the high recombination rate and low surface area. Although several scientists have examined the heterojunction of TiO_2 and g-C_3N_4 since it has a high surface area, decreases electrons recombination, and absorbs visible light. The photocatalytic performance has not progressed significantly [17].

The hydrothermal bio-template procedure was used to generate a C-doped g-C_3N_4 effectively using the carbonization procedure at 500 °C and nitrogen-coated titanium dioxide as a core-shell heterojunction photocatalyst. During constructing a core-shell heterojunction photocatalyst, kapok fiber was exploited as a bio-template and in-situ carbon coated in CN and titanium dioxide. Furthermore, urea application as a g-C_3N_4 precursor contributes to band-gap narrowing in TiO_2 via in-situ C and N loading. Several characterization approaches were used to investigate the impact of TiO_2 source amount on the formation of core-shell nanocomposite heterojunction photocatalysts, which can impact and enhance catalytic performance. The photoelectrochemical and photoluminescence investigations revealed that the bio-template core-shell nanocomposite heterojunction photocatalysts had a remarkable improvement in photoinduced electron-hole dissociation performance. The improved photogenerated charge carrier dispersion and shorter band gap lead to enhanced photocatalytic activity, with the CCN/T-1.5 material producing the most hydrogen (625.5 μmol h^{-1} g^{-1}) in methanol medium [18].

Based on Wang et al., 2014, the generated KF with or CKF/AuNPs/CTS nano-composites exhibit excellent catalytic performance and durability for the catalytic reduction decolorization of CR dye, with the color of the CR solution rapidly fading within Three minutes at a modest catalyst dosing of 0.3 g/L. Furthermore, after 20 min of sonication or 1 mol/L acid treatment, the nanocomposite's catalytic performance can be sustained. The hydrogen was created concurrently with the catalytic decolorization of CR and can be recovered as a clean, renewable energy, with a total output of 430 mL/L. As a result, the nanostructure could be utilized as a catalyst to decolorize dye effluent and create H_2 in a single cycle [19]. The absorbance peak at 533 nm was definitely observable in the UV–vis spectra of KF/CTS/AuNPs and CKF/CTS/AuNPs, confirming that the AuNPs were effectively bonded on the membrane of CTS-coated KF and CKF as predicted . This finding is also clearly displayed in the test procedure, where the purple-red AuNPs solution becomes colorless when added to CTS-coated KF or CKF.

The application of the nano-structure as a catalyst is critical to practical usage. It can be noticed that the color removal rate has not decreased significantly, and 92.6% of the original dye removal rate was attained following nine recoveries. This suggests that the nanocomposite could be used as a reusable catalytic substance for dye removal.

In summary, inserting kapok fiber-based carbon loading in the semiconductor structure using a simple bio-template synthesis technique can improve photocatalytic hydrogen generation in pure semiconductors. Furthermore, a well-constructed mesoporous micro-tubular structure was produced during the fabrication of a C-doped semiconductor employing treated kapok fiber. The generated C-doped semiconductor's band gap structure and quantity of carbon doping may be easily modified using various impregnation processes. It should be highlighted that the significant increase in photocatalytic performance was due to improved light absorption, an acceptable energy band gap, and quick photogenerated carrier transfer and separation. Developing the C-doped semiconductor-based heterojunction photocatalyst in conjunction with other semiconductor materials can also aid in creating a highly excellent photocatalyst.

2. Photocatalytic Degradation

Several years ago, the elimination of color was accomplished through adsorbents depending on electron-hole pair contact. However, changes in the shape and texture of photocatalytic components have a favorable impact on the characteristics, such as surface area and photon carrying capacity, which is accompanied by the mobilization of electrons and holes along with the shape [20][21]. Several studies have proven the multiple photocatalytic abilities of several photocatalytic substances for the degradation of various organic molecules available in water, particularly colors, up to the present day [22][23][24][25]. All of these research findings on photocatalytic applications for contaminant degradation show that the bandgap, electron-hole recombination rate, size and shape, crystallinity, phase composition, light infiltration through photocatalytic substances, surface area, and dye adsorption potential on the surface of photocatalysts are important criteria for photocatalytic operation improvement. [26]. Depending on this, scientists have become interested in producing higher surface area photocatalysts, which can offer a larger surface area and more significant dye adsorption on the interface of these compounds.

Metal sulfide-based semiconductors are the most notable photocatalysts among the highly regarded photocatalysts for the removal or dissolution of colors in wastewater applications with minimal expenses, environmentally beneficial, and durable treatment solutions for environmental preservation. In previous decades, environmental contamination has become a severe hazard to the ecosystem and public safety. To combat pollution, loaded and heterojunction-based semiconductor metal sulfide nanostructures (MSNSs) are being explored as photocatalysts for photocatalytic removal or to eliminate massive industrial colors in an environmentally benign and durable approach. In the 1970s, the photocatalytic processing of water splitting to produce hydrogen on semiconductor nanostructures was discovered. The project will then discover the underlying mechanisms that result in photocatalysis and increase the system of photocatalytic removal performance [27]. The bandgap, surface area, quantity of catalyst, and formation of an electron-hole pair are all critical parameters in the photocatalytic removal of hazardous chemicals in an aqueous medium. It has been discovered that, among all parameters, the surface area has a crucial impact on the photocatalytic removal of colors by giving a larger surface area, which results in the increase of dye particle adsorption on the membrane of the photocatalyst and increases photocatalytic effectiveness. Based on the capacity to solve energy and environmental challenges, heterogeneous photocatalysis utilizing semiconductors has gained a lot of interest in recent years as an environmentally friendly and durable solution. Depending on heterogeneous photocatalysis, the analysis of the latest advancements in the synthesizing and usage of semiconductor MSNSs as photocatalysts in the field of heterogeneous photocatalytic removal of multiple colorings by ranging diverse settings like the size of the components, bandgap, light intensity, surface area, and dye solution concentration levels; and their relations with aquatic pollutants [28].

3. Adsorption Using KF

Spontaneous and purposeful oil spills have emerged regularly throughout shipping, manufacturing, and refinement in recent decades, resulting in significant negative consequences for individuals and the natural system [29][30]. Oil-absorbing substances are commonly recognized as the most successful for removing and recovering wasted oil. They are classified into inorganic mineral substances, chemically synthesized polymers, and natural organic components [31][32]. Graphite, organic clay, vermiculite, silica, perlite, fly ash, and zeolites are examples of inorganic mineral minerals [33][34][35][36][37][38][39]. In recent decades, polyacrylate, polyethylene, and polypropylene, a new substance for adsorbing oil, are synthesized organic polymers [39][40][41][42]. Various agricultural items are used in organic natural resources, including cotton fiber, kenaf, straw, milkweed, sawdust, and straw kapok fiber [43][44][45]. Among these organic products, kapok offers several benefits over typical oil-absorbing materials, including inexpensiveness, renewability, innate hydrophobicity, and high sorption ability, making it desirable as an oil-absorbing substance [46]. All recent research regarding the adsorption application of kapok fiber is illustrated in **Table 1**.

Table 1. Summary of adsorption application of Kapok Fiber.

Materials	Pollutants	Adsorption Results	References
Polyaniline-kapok fiber-nanocomposite	Anionic-methyl-orange	136.75 mg/g	[47]
Kapok fiber	Methylene blue	110.13 mg/g	[48]
Polyaniline-kapok fiber-nanocomposite	Lead ions	78.34 mg/g	[49]
Polyacrylonitrile-coated-kapok hollow-microtube	methyl-orange & Cu (II) ions	34.72/90.09 mg/g	[50]
Kapok fiber-oriented polyaniline	Sulfonated dyes	192.3 mg/g	[51]
Kapok fiber-oriented polyaniline-nanofiber	Cu (II) ions	145.54 mg/g	[51]
Polyaniline-coated kapok fiber	Methyl-orange & copper (II) ions	81.04 mg/g	[52]
Hydrophilic modified kapok fiber	Lead(II)	94.41 mg/g	[53]
Acetylated modification kapok fiber	Oil	84.4 g/g	[54]
Oxidized kapok fiber	Pb, Cu, Cd and Zn	93.55%, 91.83%, 89.75% and 92.85%	[55]
Kapok fiber-based carbon microtube aerogel	Oil/organic solvents	98% (distillation) 97% (Squeezing) 90% (Combustion)	[56]
DTPA-modified kapok fiber	Pb^{+2}, Cd^{+2}, Cu^{+2}	310.6 mg/g, 163.7 mg/g, 101 mg/g	[57]
Kapok fiber	Diesel	45 g/g	[58]
Kapok fiber	Oil	32.31 g/g	[59]
Raw kapok fiber/pyridine-catalyzed kapok Fiber/NBS-catalyzed kapok fiber	Diesel	30.5 g/g 36.7 g/g 34 g/g	[60]
PBMA/SiO_2	Diesel, Soybean oil, Crude oil, 150SN,	99.7%, 65%, 41.1%, 23.1% and 26.8%	[61]

Materials	Pollutants	Adsorption Results	References
	20CST		
PBMA-Kapok Fiber	Toluene and chloroform	14.6 g/g and 26 g/g	[62]
Superhydrophobic—Kapok Fiber	Diesel and Soybean oil	46.9 g/g and 58.8	[63]
Kapok Fiber—Dopamine	Mercury	235.7 mg/g	[64]

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With global warming and resource scarcity becoming increasingly extreme, the electrochemical CO_2 minimization process (ECO_2RR) is an effective and intriguing strategy to convert CO_2 into various valuation compounds as a carbon-neutral way to a sustainable power source [65][66][67]. Among the several compounds created by CO_2 electroreduction, formate or formic acid is a significant fluid biofuel that can be effectively exploited as a super-economic power transporter in fuel cell applications [68][69][70]. Biodegradable resources (animal or botanic) are near-ideal solutions for the synthesis of several high-production catalysts, which have numerous essential advantages, such as inexpensive cost, easy availability, and molecular and geometrical variations [71][72][73]. Kapok fiber is an organic porous fiber generated from the silk-cotton tree with a significant cavity and a thinner covering and is used as an oil and heavy metal ion adsorbent [57][60]. Furthermore, kapok fiber is an ideal carbon source for the fabrication of electrochemical supercapacitors [74][75]. The use of kapok fiber in electrochemical CO_2 removal, on the other hand, has never been recorded. The enormous cylindrical form of kapok-tubes is advantageous for carrying metal nanoparticles; also, kapok-tube has a high capacity for metal ion capturing due to its numerous oxygen active element on the membranes [49][76]. Most of the evidence suggests that it can be used as a novel carbon substrate to manufacture electrocatalysts. The kapok tube is mainly employed as a carbon electrocatalyst for Carbon dioxide electroreduction, and it performs well for electrocatalytic Carbon dioxide to fluid energy conversion without adding active components. Unlike typical carbon nanotubes and graphene, which have weak capacities for formate generation without adding active components, this natural capacity may be attributed to the many mesoporous structures found in MHKTs, which acted as functional spots for formate generation. Additionally, the kapok tube is used for the first time as a novel catalyst substrate for depositing metal nanoparticles in electrocatalytic CO_2 removal. All the metals in-situ bonded on MHKTs are manufactured using a simple one-pot synthetic technique. For the CO_2-to-formate process, the four electro-catalysts, Sn, Bi, Pb, and Cd-MHKTs, exhibited great selection, low overpotential, high existing density, and prolonged stability. These low-cost metal MHKT electrocatalysts offer many potential applications in electrocatalytic CO_2 degradation to formate.

In conclusion, the usage of Kapok fiber for CO_2 conversion under visible light to create solar fuels is discussed, as well as how various properties and structural adjustments may impact the processes and final products. The presence of a flexible structure for adjusting band gaps and imparting lattice distortion allows kapok fiber to control separation, mobility, and the lifetime of photogenerated charges. Demonstrating good selectivity for format generation across a wide range of potentials. The use of kapok fiber offers fresh insight into the production of innovative carbon supports with suitable photocatalytic characteristics.

References

1. Kumar, P.; Boukherroub, R.; Shankar, K. Sunlight-driven water-splitting using two-dimensional carbon based semiconductors. J. Mater. Chem. A 2018, 6, 12876–12931.
2. Zou, X.; Zhang, Y. Noble metal-free hydrogen evolution catalysts for water splitting. Chem. Soc. Rev. 2015, 44, 5148–5180.
3. Sharma, S.; Ghoshal, S.K. Hydrogen the future transportation fuel: From production to applications. Renew. Sustain. Energy Rev. 2015, 43, 1151–1158.
4. AlZahrani, A.A.; Dincer, I. Modeling and performance optimization of a solid oxide electrolysis system for hydrogen production. Appl. Energy 2018, 225, 471–485.
5. Swaren, L.; Safari, S.; Konhauser, K.O.; Alessi, D.S. Pyrolyzed biomass-derived nanoparticles: A review of surface chemistry, contaminant mobility, and future research avenues to fill the gaps. Biochar 2022, 4, 33.
6. Ma, M.; Yang, L.; Ouyang, L.; Shao, H.; Zhu, M. Promoting hydrogen generation from the hydrolysis of Mg-Graphite composites by plasma-assisted milling. Energy 2019, 167, 1205–1211.
7. Chen, K.; Ouyang, L.; Zhong, H.; Liu, J.; Wang, H.; Shao, H.; Zhang, Y.; Zhu, M. Converting H+ from coordinated water into H− enables super facile synthesis of LiBH4. Green Chem. 2019, 21, 4380–4387.
8. Ouyang, L.; Chen, W.; Liu, J.; Felderhoff, M.; Wang, H.; Zhu, M. Enhancing the Regeneration Process of Consumed NaBH4 for Hydrogen Storage. Adv. Eng. Mater. 2017, 7, 1700299.
9. Tan, Z.H.; Ouyang, L.Z.; Huang, J.M.; Liu, J.W.; Wang, H.; Shao, H.Y.; Zhu, M. Hydrogen generation via hydrolysis of Mg2Si. J. Alloys Compd. 2019, 770, 108–115.
10. Shi, J.; Feng, S.; Chen, T.; Liu, Z.; Yue, X. High-efficiency visible light photocatalytic performances of the CdS(HS)/g-C3N4 composites: The role of intimate connection and hollow structure. J. Mater. Sci. Mater. Electron. 2019, 30, 10867–10878.
11. Shekofteh-Gohari, M.; Habibi-Yangjeh, A.; Abitorabi, M.; Rouhi, A. Magnetically separable nanocomposites based on ZnO and their applications in photocatalytic processes: A review. Crit. Rev. Environ. Sci. Technol. 2018, 48, 806–857.
12. Symes, M.D.; Cronin, L. Decoupling hydrogen and oxygen evolution during electrolytic water splitting using an electron-coupled-proton buffer. Nat. Chem. 2013, 5, 403–409.
13. Sun, H.S.; Sun, M.; Fang, Y.; Wang, Y.; Wang, H. One-step in situ calcination synthesis of g-C3N4/N-TiO2 hybrids with enhanced photoactivity. RSC Adv. 2016, 6, 13063–13071.
14. Nasir, M.S.; Yang, G.; Ayub, I.; Wang, S.; Wang, L.; Wang, X.; Yan, W.; Peng, S.; Ramakarishna, S. Recent development in graphitic carbon nitride based photocatalysis for hydrogen generation. Appl. Catal. B 2019, 257, 117855.

15. Zeng, Y.; Liu, X.; Liu, C.; Wang, L.; Xia, Y.; Zhang, S.; Luo, S.; Pei, Y. Scalable one-step production of porous oxygen-doped g-C3N4 nanorods with effective electron separation for excellent visible-light photocatalytic activity. Appl. Catal. B 2018, 224, 1–9.
16. Li, C.; Sun, Z.; Zhang, W.; Yu, C.; Zheng, S. Highly efficient g-C3N4/TiO2/kaolinite composite with novel three-dimensional structure and enhanced visible light responding ability towards ciprofloxacin and S. aureus. Appl. Catal. B 2018, 220, 272–282.
17. Shi, Z.-L.; Du, C.; Yao, S.-H. Preparation and photocatalytic activity of cerium doped anatase titanium dioxide coated magnetite composite. J. Taiwan Inst. Chem. Eng. 2011, 42, 652–657.
18. Mohamed, M.A.; Zain, M.F.M.; Minggu, L.J.; Kassim, M.B.; Jaafar, J.; Amin, N.A.S.; Ng, Y.H. Revealing the role of kapok fibre as bio-template for In-situ construction of C-doped g-C3N4@C, N co-doped TiO2 core-shell heterojunction photocatalyst and its photocatalytic hydrogen production performance. Appl. Surf. Sci. 2019, 476, 205–220.
19. Wang, W.; Wang, F.; Kang, Y.; Wang, A. Au nanoparticles decorated Kapok fiber by a facile noncovalent approach for efficient catalytic decoloration of Congo Red and hydrogen production. Chem. Eng. J. 2014, 237, 336–343.
20. Azad Kumar, D.K.; Pandey, G. Characterisation of hydrothermally synthesised cuo nanoparticles at different pH. J. Technol. Adv. Sci. Res. 2016, 2, 166–169.
21. Natarajan, T.S.; Natarajan, K.; Bajaj, H.C.; Tayade, R.J. Enhanced photocatalytic activity of bismuth-doped TiO2 nanotubes under direct sunlight irradiation for degradation of Rhodamine B dye. J. Nanopart. Res. 2013, 15, 1669.
22. Etacheri, V.; di Valentin, C.; Schneider, J.; Bahnemann, D.; Pillai, S.C. Visible-light activation of TiO2 photocatalysts: Advances in theory and experiments. J. Photochem. Photobiol. C 2015, 25, 1–29.
23. Abou-Gamra, Z.M.; Ahmed, M.A. Synthesis of mesoporous TiO2-curcumin nanoparticles for photocatalytic degradation of methylene blue dye. J. Photochem. Photobiol. B 2016, 160, 134–141.
24. Wu, F.; Liu, W.; Qiu, J.; Li, J.; Zhou, W.; Fang, Y.; Zhang, S.; Li, X. Enhanced photocatalytic degradation and adsorption of methylene blue via TiO2 nanocrystals supported on graphene-like bamboo charcoal. Appl. Surf. Sci. 2015, 358, 425–435.
25. Hamad, H.A.; Sadik, W.A.; El-Latif, M.M.A.; Kashyout, A.B.; Feteha, M.Y. Photocatalytic parameters and kinetic study for degradation of dichlorophenol-indophenol (DCPIP) dye using highly active mesoporous TiO2 nanoparticles. J. Environ. Sci. 2016, 43, 26–39.
26. Anandan, S.; Yoon, M. Photocatalytic activities of the nano-sized TiO2-supported Y-zeolites. J. Photochem. Photobiol. C 2003, 4, 5–18.

27. Beer, C.; Foldbjerg, R.; Hayashi, Y.; Sutherland, D.S.; Autrup, H. Toxicity of silver nanoparticles—Nanoparticle or silver ion? Toxicol. Lett. 2012, 208, 286–292.
28. Ayodhya, D.; Veerabhadram, G. A review on recent advances in photodegradation of dyes using doped and heterojunction based semiconductor metal sulfide nanostructures for environmental protection. Mater. Today Energy 2018, 9, 83–113.
29. Aguilera, F.; Mendez, J.; Pasaro, E.; Laffon, B. Review on the effects of exposure to spilled oils on human health. J. Appl. Toxicol. 2010, 30, 291–301.
30. Arques, A.; Amat, A.M.; Santos-Juanes, L.; Vercher, R.F.; Marín, M.L.; Miranda, M.A. 2,4,6-Triphenylthiapyrylium cation as homogeneous solar photocatalyst. Catal. Today 2007, 129, 37–42.
31. Adebajo, M.O.; Frost, R.L.; Kloprogge, J.T.; Carmody, O.; Kokot, S. Porous Materials for Oil Spill Cleanup: A Review of Synthesis. and Absorbing Properties. J. Porous Mater. 2003, 10, 159–170.
32. Deschamps, G.; Caruel, H.; Borredon, M.-E.; Bonnin, C.; Vignoles, C. Oil Removal from Water by Selective Sorption on Hydrophobic Cotton Fibers. 1. Study of Sorption Properties and Comparison with Other Cotton Fiber-Based Sorbents. Environ. Sci. Technol. 2003, 37, 1013–1015.
33. Inagaki, M.; Konno, H.; Toyoda, M.; Moriya, K.; Kihara, T. Sorption and recovery of heavy oils by using exfoliated graphite Part II: Recovery of heavy oil and recycling of exfoliated graphite. Desalination 2000, 128, 213–218.
34. Bastani, D.; Safekordi, A.A.; Alihosseini, A.; Taghikhani, V. Study of oil sorption by expanded perlite at 298.15K. Sep. Purif. Technol. 2006, 52, 295–300.
35. Teas, C.; Kalligeros, S.; Zanikos, F.; Stournas, S.; Lois, E.; Anastopoulos, G. Anastopoulos Investigation of the effectiveness of absorbent materials in oil spills clean up. Desalination 2001, 140, 259–264.
36. Mysore, D.; Viraraghavan, T.; Jin, Y.C. Treatment of oily waters using vermiculite. Water Res. 2005, 39, 2643–2653.
37. Carmody, O.; Frost, R.; Xi, Y.; Kokot, S. Adsorption of hydrocarbons on organo-clays—Implications for oil spill remediation. J. Colloid Interface Sci. 2007, 305, 17–24.
38. Viraraghavan, H.M.A.T. Coalescence/Filtration of an Oil-In-Water Emulsion in a Granular Organo-Clay/Anthracite Mixture Bed, Water, Air. Soil Pollut. 2002, 138, 253–270.
39. Banerjee, S.S.; Joshi, M.V.; Jayaram, R.V. Treatment of oil spills using organo-fly ash. Desalination 2006, 195, 32–39.
40. Wei, Q.F.; Mather, R.R.; Fotheringham, A.F.; Yang, R.D. Evaluation of nonwoven polypropylene oil sorbents in marine oil-spill recovery. Mar. Pollut. Bull. 2003, 46, 780–783.

41. Essawy, H.A.; Essa, M.M.; Abdeen, Z. Oil-absorptive polymeric networks based on dispersed oleophilized nanolayers of laponite within ethylene-propylene-diene monomer vulcanizates. J. Appl. Polym. Sci. 2010, 115, 385–392.
42. Xu, B.N.; Xiao, C. A Novel Absorptive Functional Fiber Copolymerized by Butyl Methacrylate with Hydroxyethyl Methacrylate: Preparation and Characterization. Polym.-Plast. Technol. Eng. 2009, 49, 95–103.
43. Annunciado, T.R.; Sydenstricker, T.H.; Amico, S.C. Experimental investigation of various vegetable fibers as sorbent materials for oil spills. Mar. Pollut. Bull. 2005, 50, 1340–1346.
44. Suni, S.; Kosunen, A.L.; Hautala, M.; Pasila, A.; Romantschuk, M. Use of a by-product of peat excavation, cotton grass fibre, as a sorbent for oil-spills. Mar. Pollut. Bull. 2004, 49, 916–921.
45. Hyung-Min Choi, J.P.M. Oil sorption behavior of various sorbents studied by sorption capacity measurement and environmental scanning electron microscopy. Microsc. Res. Tech. 1993, 25, 447–455.
46. Matuana, L.M.; Balatinecz, J.J.; Sodhi, R.N.; Park, C.B. Park Surface characterization of esterified cellulosic fibers by XPS and FTIR Spectroscopy. Wood Sci. Technol. 2001, 35, 191–201.
47. Zheng, Y.; Liu, Y.; Wang, A. Kapok Fiber Oriented Polyaniline for Removal of Sulfonated Dyes. Ind. Eng. Chem. Res. 2012, 51, 10079–10087.
48. Liu, Y.; Wang, J.; Zheng, Y.; Wang, A. Adsorption of methylene blue by kapok fiber treated by sodium chlorite optimized with response surface methodology. Chem. Eng. J. 2012, 184, 248–255.
49. Balela, M.D.L.; Intila, N.M.; Salvanera, S.R. Adsorptive Removal of Lead Ions in Aqueous Solution by Kapok-Polyacrylonitrile Nanocomposites. Mater. Today Proc. 2019, 17, 672–678.
50. Agcaoili, A.R.; Herrera, M.U.; Futalan, C.M.; Balela, M.D.L. Fabrication of polyacrylonitrile-coated kapok hollow microtubes for adsorption of methyl orange and Cu(II) ions in aqueous solution. J. Taiwan Inst. Chem. Eng. 2017, 78, 359–369.
51. Zheng, Y.; Wang, W.; Huang, D.; Wang, A. Kapok fiber oriented-polyaniline nanofibers for efficient Cr(VI) removal. Chem. Eng. J. 2012, 191, 154–161.
52. Herrera, M.U.; Futalan, C.M.; Gapusan, R.; Balela, M.D.L. Removal of methyl orange dye and copper (II) ions from aqueous solution using polyaniline-coated kapok (Ceiba pentandra) fibers. Water Sci. Technol. 2018, 78, 1137–1147.
53. Wang, D.; Kim, D.; Shin, C.-H.; Zhao, Y.; Park, J.-S.; Ryu, M. Removal of lead(II) from aqueous stream by hydrophilic modified kapok fiber using the Fenton reaction. Environ. Earth Sci. 2018, 77, 653.

54. Wang, J.; Wang, A. Acetylated modification of kapok fiber and application for oil absorption. Fibers Polym. 2013, 14, 1834–1840.
55. Chung, B.-Y.; Cho, J.-Y.; Lee, M.-H.; Wi, S.-G.; Kim, J.-H.; Kim, J.-S.; Kang, P.-H.; Nho, Y.-C. Adsorption of Heavy Metal Ions onto Chemically Oxidized Ceiba pentandra (L.) Gaertn. (Kapok) Fibers. J. Korean Soc. Appl. Biol. Chem. 2008, 51, 28–35.
56. Song, P.; Cui, J.; Di, J.; Liu, D.; Xu, M.; Tang, B.; Zeng, Q.; Xiong, J.; Wang, C.; He, Q.; et al. Carbon Microtube Aerogel Derived from Kapok Fiber: An Efficient and Recyclable Sorbent for Oils and Organic Solvents. ACS Nano 2020, 14, 595–602.
57. Duan, C.; Zhao, N.; Yu, X.; Zhang, X.; Xu, J. Chemically modified kapok fiber for fast adsorption of Pb2+, Cd2+, Cu2+ from aqueous solution. Cellulose 2013, 20, 849–860.
58. Lim, T.-T.; Huang, X. Evaluation of kapok (Ceiba pentandra (L.) Gaertn.) as a natural hollow hydrophobic-oleophilic fibrous sorbent for oil spill cleanup. Chemosphere 2007, 66, 955–963.
59. Dong, T.; Cao, S.; Xu, G. Highly efficient and recyclable depth filtrating system using structured kapok filters for oil removal and recovery from wastewater. J. Hazard. Mater. 2017, 321, 859–867.
60. Wang, J.; Zheng, Y.; Wang, A. Investigation of acetylated kapok fibers on the sorption of oil in water. J. Environ. Sci. 2013, 25, 246–253.
61. Wang, J.; Zheng, Y.; Kang, Y.; Wang, A. Investigation of oil sorption capability of PBMA/SiO2 coated kapok fiber. Chem. Eng. J. 2013, 223, 632–637.
62. Wang, J.; Zheng, Y.; Wang, A. Preparation and properties of kapok fiber enhanced oil sorption resins by suspended emulsion polymerization. J. Appl. Polym. Sci. 2013, 127, 2184–2191.
63. Wang, J.; Zheng, Y.; Wang, A. Superhydrophobic kapok fiber oil-absorbent: Preparation and high oil absorbency. Chem. Eng. J. 2012, 213, 1–7.
64. Yang, N.; Shin, C.-H.; Kim, D.; Park, J.-S.; Rao, P.; Wang, R. Synthesis, characterization, and mercury removal application of surface modified kapok fibers with dopamine (DA): Investigation of bidentate adsorption. Environ. Earth Sci. 2020, 79, 264.
65. Qiao, J.; Liu, Y.; Hong, F.; Zhang, J. A review of catalysts for the electroreduction of carbon dioxide to produce low-carbon fuels. Chem. Soc. Rev. 2014, 43, 631–675.
66. Fan, L.; Xia, Z.; Xu, M.; Lu, Y.; Li, Z. 1D SnO2 with Wire-in-Tube Architectures for Highly Selective Electrochemical Reduction of CO2 to C1 Products. Adv. Funct. Mater. 2018, 28, 1706289.
67. Huang, J.; Guo, X.; Yue, G.; Hu, Q.; Wang, L. Boosting CH3OH Production in Electrocatalytic CO2 Reduction over Partially Oxidized 5 nm Cobalt Nanoparticles Dispersed on Single-Layer Nitrogen-Doped Graphene. ACS Appl. Mater. Interfaces 2018, 10, 44403–44414.

68. Li, F.; Chen, L.; Knowles, G.P.; MacFarlane, D.R.; Zhang, J. Hierarchical Mesoporous SnO_2 Nanosheets on Carbon Cloth: A Robust and Flexible Electrocatalyst for CO_2 Reduction with High Efficiency and Selectivity. Angew. Chem. Int. Ed. Engl. 2017, 56, 505–509.
69. Li, F.; Chen, L.; Xue, M.; Williams, T.; Zhang, Y.; MacFarlane, D.R.; Zhang, J. Towards a better Sn: Efficient electrocatalytic reduction of CO_2 to formate by Sn/SnS_2 derived from SnS_2 nanosheets. Nano Energy 2016, 31, 270–277.
70. Fan, W.K.; Tahir, M. Structured clay minerals-based nanomaterials for sustainable photo/thermal carbon dioxide conversion to cleaner fuels: A critical review. Sci. Total Environ. 2022, 845, 157206.
71. Liu, B.F.; Peng, H.; You, C.; Fu, Z.; Huang, P.; Song, H.; Liao, S. High-Performance Doped Carbon Catalyst Derived from Nori Biomass with Melamine Promoter. Electrochim. Acta 2014, 138, 353–359.
72. Song, H.; Xu, S.; Li, Y.; Dai, J.; Gong, A.; Zhu, M.; Zhu, C.; Chen, C.; Chen, Y.; Yao, Y.; et al. Hierarchically Porous, Ultrathick, “Breathable” Wood-Derived Cathode for Lithium-Oxygen Batteries. Adv. Eng. Mater. 2017, 8, 1701203.
73. Zhu, C.; Du, L.; Luo, J.; Tang, H.; Cui, Z.; Song, H.; Liao, S. A renewable wood-derived cathode for Li–O_2 batteries. J. Mater. Chem. A 2018, 6, 14291–14298.
74. Xu, W.; Mu, B.; Wang, A. Facile fabrication of well-defined microtubular carbonized kapok fiber/NiO composites as electrode material for supercapacitor. Electrochim. Acta 2016, 194, 84–94.
75. Cao, Y.; Xie, L.; Sun, G.; Su, F.; Kong, Q.-Q.; Li, F.; Ma, W.; Shi, J.; Jiang, D.; Lu, C.; et al. Hollow carbon microtubes from kapok fiber: Structural evolution and energy storage performance. Sustain. Energy Fuels 2018, 2, 455–465.
76. Angin, D. Effect of pyrolysis temperature and heating rate on biochar obtained from pyrolysis of safflower seed press cake. Bioresour. Technol. 2013, 128, 593–597.