Supporting Information

Waste to Wealth and Safer Bio-based Flame Retardant: A Novel Approach Towards Phosphorus-Functionalized Chitosan-Banana Pseudo-Stem Composite

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Abbreviations

Banana Pseudo-Stem SAP (BPS)

Chitosan-Banana Pseudo-Stem Composite (CBPS)

Phosphorus-Functionalized Chitosan-Banana Pseudo-Stem Composite (P-CBPS)

Banana Pseudo Stem Juice Coated Cotton Cloth (BPS-C)

Chitosan-Banana Pseudo-Stem Composite Coated Cotton Cloth (CBPS-C)

Phosphorus-Functionalized Chitosan-Banana Pseudo-Stem Composite Coated Cotton Cloth (P-CBPS-C)

Characterization

The catalyst characterization involved several analytical techniques. Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) were conducted using a Model 449 F3 (Netzsch, Selb, Germany) in an aluminium pot with a nitrogen flow rate of 0.833 mL/sec. For Fourier Transform Infrared Spectroscopy (FTIR), Perkin Elmer equipment was utilized. Samples were prepared with clean potassium bromide (KBr) pellets in a KBr-to-sample ratio of approximately 100:1, which were then pressed into pellets. FTIR spectra of the catalyst pellets were recorded at room temperature over a wavenumber range of 4000–500 cm^(-1) with a resolution of 2 cm^(-1). Field Emission Scanning Electron Microscopy (FESEM) was performed using a Carl Zeiss Model Supra 55 (Germany) to capture detailed images of the catalyst surface and analyze its elemental composition. X-ray Photoelectron Spectroscopy (XPS) was carried out with a Kratos, HP/Kratos Analytical instrument, using a 15 mA emission current and analyzing from 0 to 1200 eV in 1205 steps of 1 eV each. The XPS analysis, conducted with 225 W X-ray power, examined the surface characteristics and elemental composition of the catalyst. The Limiting Oxygen Index (LOI) percentage was measured with a Limiting Oxygen Index tester, while the char length was determined using a vertical flammability tester. For the LOI analysis and the spirit lamp test, fabric samples were cut to dimensions of 5 cm x 10 cm, and for the vertical flammability test, the fabric was cut to 10 cm x 30 cm. The flame test was performed using a simple spirit lamp test.

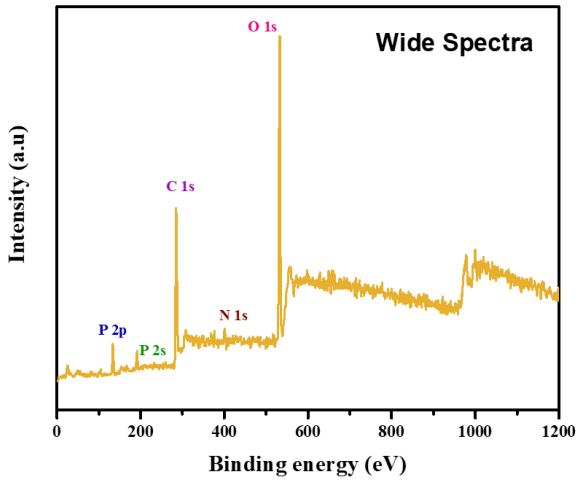

Figure S1: XPS wide spectra of P-CBPS-C

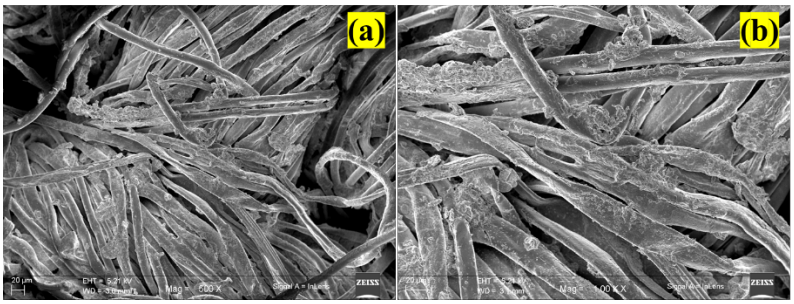

Figure S2: SEM Image of (a) BPS-C (b) CBPS-C

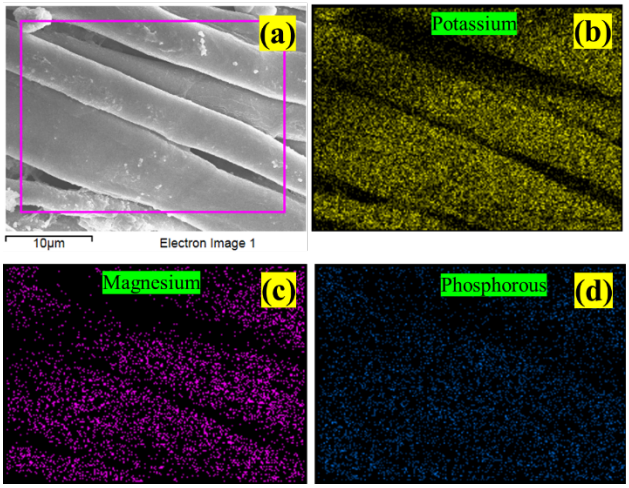

Figure S3: EDX elemental mapping of the BPS-C

Flame test Video link

Video S1 showing P-CBPS coated cloth vs blank cloth flame retardancy test https://drive.google.com/file/d/1biB0uwRwdgi0uxANDk-qJbz-SOLrHV29/view?usp=drive_link

Video S2 showing BPS coated cloth vs blank cloth flame retardancy test https://drive.google.com/file/d/19uabDN0RkLP6ZRgk3R8G7bTPFq-Wyyhu/view?usp=drive_link

Video S3 showing CBPS coated cloth vs blank cloth flame retardancy test https://drive.google.com/file/d/1SfK0ycY28eOUlTq5yzR59D8S839vOy-Q/view?usp=drive_link

Tensile strength

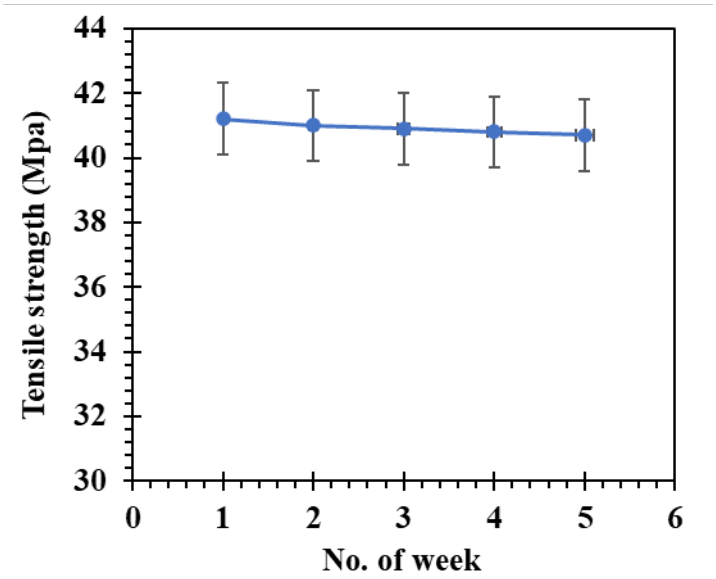

Figure S4: Tensile strength of P-CBPS-C

Washing fastness (Durability study)

Figure S5: Photos of vertically flammability test: (a) P-CBPS-C (b) Washing fastness after 3rd washed (P-CBPS-C)

Table S1: XPS data of the P-CBPS-C.

Element	BE [eV]	FWHM [eV]	Atomic conc. [%]	Error [%]	Mass conc. [%]	Error [%]
Mg 2p	49.60	3.67	1.8	1.08	2.8	1.69
P 2p	133.60	2.59	4.8	0.56	9.6	1.08
C 1s	284.60	3.47	51.6	1.51	38.9	1.64
O 1s	532.60	3.18	31.1	1.14	32	1.34
N 1s	400.60	4.14	3.6	1.01	3.3	0.93

P 2s	191.60	2.92	4.8	0.94	9.6	1.81
K 2p	292.87	2.29	2.3	1.03	3.8	1.54

Table S2: EDX, data of BPS-C.

Elements	Weight %
Carbon	44.9
Oxygen	37.3
Potassium	11.2
Magnesium	4.9
Phosphorous	1.7

Table S3: ICP-AES analysis of BPS

Elements (Minerals)	mg/L
Mg	125.5
K	1351.3
Phosphorous	4.5

Table S4: CBPS % loading on cloth

Sample No.	Cloth (g)	CBPS-C (g)	CBPS [a] (g)	% loading of CBPS [b]
1	0.758	0.785	0.027	3.562
2	0.788	0.816	0.028	3.553
3	0.775	0.804	0.029	3.742
4	0.768	0.794	0.026	3.385
5	0.769	0.794	0.025	3.251
Average	0.772	0.799	0.027	3.50

Table S5: BPS % loading on cloth

Sample No.	Cloth (g)	BPS-C (g)	BPS [a] (g)	% loading of BPS [b]
1	0.756	0.763	0.007	0.926
2	0.768	0.776	0.008	1.042
3	0.785	0.791	0.006	0.764
4	0.773	0.778	0.005	0.647
5	0.778	0.785	0.007	0.900
Average	0.772	0.779	0.0066	0.86