

Supporting Information

Experimental Reagents

Sodium carbonate (Na_2CO_3), AR grade, Sinopharm Chemical Reagent Co., Ltd.; Sodium hydroxide (NaOH), analytical grade, Aladdin Reagent Co., Ltd.; Dilute hydrochloric acid (HCl), industrial grade, Shenzhen Fulin Standard Titration Solution; Phytic acid (PA), AR grade, Aladdin Reagent Co., Ltd.; Chitosan (CS), AR, Aladdin Reagent Co., Ltd.; Cotton fabric, industrial-grade cloth, Hongda Weaving Factory.

Experimental details

Cotton fabric samples measuring $15 \times 15 \text{ cm}^2$ were placed in a 0.3 wt% Na_2CO_3 alkaline solution and boiled for 30 minutes. After cooling, the samples were rinsed with clean water until the fabric surface reached neutral pH, removing surface impurities and enhancing their reactivity.

The cotton fabric was subjected to layer-by-layer (LbL) assembly by alternately immersing it in chitosan (CS) and phytic acid (PA) solutions. Specifically, the fabric was first immersed in CS solutions (1, 2, or 3 wt%, pH 4-5 adjusted with 1 mol/L HCl) for 10, 15, or 20 min, followed by immersion in PA solutions (2, 2.5, or 3 wt%, pH 4-5 adjusted with 1 mol/L NaOH) for the same duration. After each immersion step, the fabric was rinsed with deionized water and then dried to constant weight in a vacuum oven at $60 \text{ }^\circ\text{C}$ (for 20 min). This cycle was repeated for 5, 8, or 10 bilayers to produce nine sample groups, denoted as $\text{C}_n/\text{CS}/\text{PA}$ (where C represents cotton and n indicates the number of bilayers). Representative samples, namely $\text{C}_5/\text{CS}/\text{PA}$, $\text{C}_8/\text{CS}/\text{PA}$, and $\text{C}_{10}/\text{CS}/\text{PA}$, were selected for further investigation.

SEM Analysis:

The surface morphology of the samples and the char residues after combustion were examined using a Nano SEM 450 scanning electron microscope. Prior to imaging, the samples were sputter-coated with a thin layer of gold to enhance conductivity. The observations were conducted at an accelerating voltage of 20 kV.

XPS:

The surface elemental composition and chemical states of the samples were analyzed by X-ray photoelectron spectroscopy (XPS) using a Kratos AXIS Ultra DLD

spectrometer (UK) with a monochromatic Al K α X-ray source.

TGA Analysis:

Thermogravimetric analysis was performed on a NETZSCH 209F3 thermogravimetric analyzer. Samples (5-7 mg) were heated from 30 to 800 °C at a rate of 10 °C/min under a nitrogen atmosphere to obtain the thermogravimetric (TG) curves.

FTIR:

FTIR analysis of the LbL-modified cotton fabric and its pyrolysis residues was performed using a Nicolet iS20 spectrometer equipped with an ATR accessory. The samples were mixed with KBr powder, finely ground, and pressed into pellets for transmission mode measurement. Spectra were recorded in the range of 4000-500 cm⁻¹ with 32 scans at a resolution of 4 cm⁻¹.

LOI:

The LOI values of the samples were determined using a Jiangning JF-3 instrument according to the GB/T 5454-1997 standard. Specimens with dimensions of 40 mm×20 mm were exposed to a mixture of nitrogen and oxygen. The LOI was defined as the minimum oxygen concentration required to sustain combustion for 2 cm of the sample length within 1 minute. The final LOI value was reported as the average of five independent measurements.

Data for limiting oxygen index (LOI)

18.3%	CF
26.7%	C5/CS
29.4%	C5/PA
28.7%	C5/CS/PA
33.4%	C8/CS/PA
36.2%	C10/CS/PA