**Supplementary Data**

**Characterization of colloid-size copper-based pesticide and its potential ecological implications**

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**Section S1: Thermal stability analysis of SRHA and SAHA samples**

Thermal gravimetric analysis (TGA) and the corresponding derivative thermal analysis (DTA) were conducted to determine the thermal stability of SRHA and SAHA samples in the range of 30-600 °C at a scan rate of 10 °C min-1. TGA and DTA measurements of SRHA and SAHA samples are shown in Fig. S2. The initial weight loss of the samples (10-17%) occurred in the range of 30-140 °C (Fig. S2a-b) could be attributed to dehydration and partial decomposition of aliphatic groups ([Chen et al., 2009](#_ENREF_2); [Siewert, 2004](#_ENREF_16)). A continuous weight loss in the range of 140-590 °C was observed for both samples. However, SRHA showed a single stage rapid weight loss in the range of 385-470 °C (Fig. S2a). The maximum observed rate of weight loss for SAHA at 296°C (Fig. S2b) could be due to thermal decomposition of alcoholic and phenolic groups, decarboxylation of acidic groups, and extensive decomposition of aliphatic structures ([Khalili and Al-Banna, 2015](#_ENREF_7); [Kolokassidou et al., 2007](#_ENREF_8); [Rotaru et al., 2008](#_ENREF_13)). The observed maximum weight loss for SRHA and SAHA at 440 °C and 455 °C, respectively, attributed to the decomposition of aromatic structures ([Chen and Tan, 2006](#_ENREF_3); [Gaál et al., 1994](#_ENREF_4); [Liu et al., 2007](#_ENREF_10)). The weight losses of SRHA and SAHA in the recorded range of temperature (30-600 °C) were 100% and 42.85%, respectively (Fig. S2a-b). On the other hand, the residual weights or ash contents of SRHA and SAHA were 0% and 57.15%, respectively (Fig. S2a-b). The different thermal degradation steps of SRHA and SAHA samples (Fig. S2a-b) indicate differences in their origin, composition, structure, and functional groups ([Li et al., 2017](#_ENREF_9)).

**Section S2: FTIR Spectroscopy analysis of SRHA and SAHA samples**

FTIR spectroscopy analysis was conducted to determine the functional groups of SRHA and SAHA samples and the resulting FTIR spectra are shown in Fig. S3. The identification of characteristic peaks of the FTIR spectra of the samples was in accordance with published reports in the literature ([Giovanela et al., 2004](#_ENREF_5); [Kačuráková and Wilson, 2001](#_ENREF_6); [Lumsdon and Fraser, 2005](#_ENREF_12); [Sharma et al., 2016](#_ENREF_14)). The FTIR spectrum of SRHA showed peaks at 1230 cm-1 (C-H stretching and the presence of hydrophilic neutral compounds), 1410 cm-1 (C-H stretching of aliphatic groups), 1615 cm-1 (aromatic C=C stretching, C=O stretching of COO-, ketonic C=O and aromatic C=C conjugated with COO-), 1710 cm-1 (C=O stretching of ketones or carboxylic groups), 1980 cm-1 and 2165 cm-1 (O-H bond or C=O stretching from carboxylic acid), and 2360 cm-1 (stretching of aliphatic C-H). The FTIR spectrum of SAHA showed bands at 700 cm-1 (O-H stretching of COO- and the presence of hydrophobic substances), 775 cm-1 and 835 cm-1 (stretching of C-O, C-O-C, and Si=C), 880 cm-1 (stretching of C-O from fatty acids and polysaccharides), 1035 cm-1 (C-O polysaccharides and/or Si-O stretching from impurities), 1320 cm-1 (C-H stretching of aliphatic groups), 1380 cm-1 (deformation of O-H and stretching of C=O from phenolic OH), 1455 cm-1 (C-H stretch of aliphatic groups), 1560 cm-1 (deformation of N-H, stretching of C≡N, and C=O stretching of COOH), 2360 cm-1 (stretching of aliphatic C-H), 2850 cm-1 (stretching of aliphatic C-H), 2920 cm-1 (stretching of aliphatic C-H), and 3360 cm-1 (stretching of free OH from OH groups). The compositional difference between SRHA and SAHA is attributed to their origin and method of extraction and preparation ([Li et al., 2017](#_ENREF_9)). This compositional difference could affect the fate, transport, and toxicity of colloidal particles or NPs ([Baken et al., 2011](#_ENREF_1); [Louie et al., 2013](#_ENREF_11); [Shen et al., 2015](#_ENREF_15)).

**Section S3: Figures**

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Fig. S1. Hydrodynamic diameter of (a) uncoated Cu-NPs and (b) carbon-coated Cu-NPs in PVP dispersant, respectively.

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Fig. S2. Thermal analysis of (a) SRHA and (b) SAHA samples based on TGA and DTA patterns.

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Fig. S3. FTIR spectra to show main functional groups of SRHA and SAHA samples based on FTIR spectroscopy analysis.

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