

## SUPPLEMENTARY MATERIALS

### Development of a Simple Reversible-Flow Method for Preparation of Micron-size Chitosan-Cu(II) Catalyst Particles and Their Testing of Activity

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#### Content

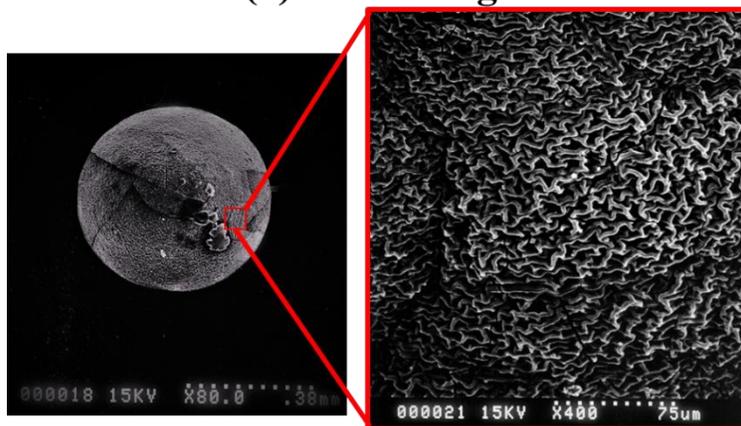
- **Supplementary Material A:** Characterization of CS-Cu(II) catalyst particles
- **Supplementary Material B:** Measurement of particle size by ImageJ software: Effect of threshold number

## Supplementary Material A

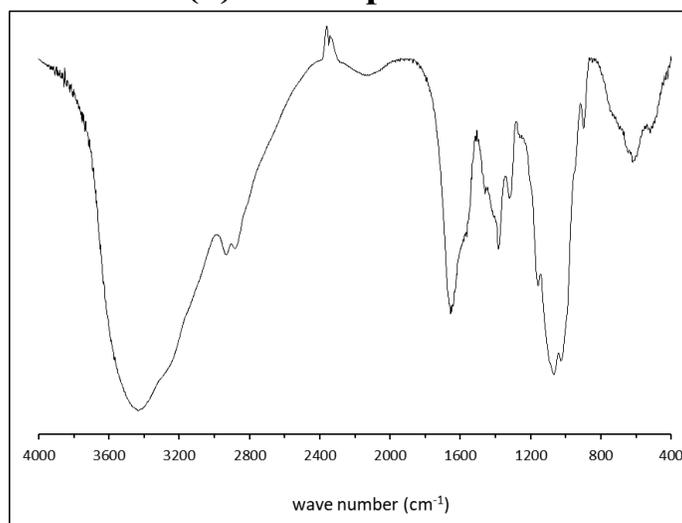
### Characterization of CS-Cu(II) catalyst particles

Characterization of chitosan-Cu(II) catalyst particles were carried out by: **(a)** scanning electron microscopy (SEM), **(b)** Fourier transform spectroscopy (FTIR), **(c)** x-ray diffraction (XRD), **(d)** specific surface areas (nitrogen adsorption/desorption isotherms) and **(e)** measurement of pore size distribution [1].

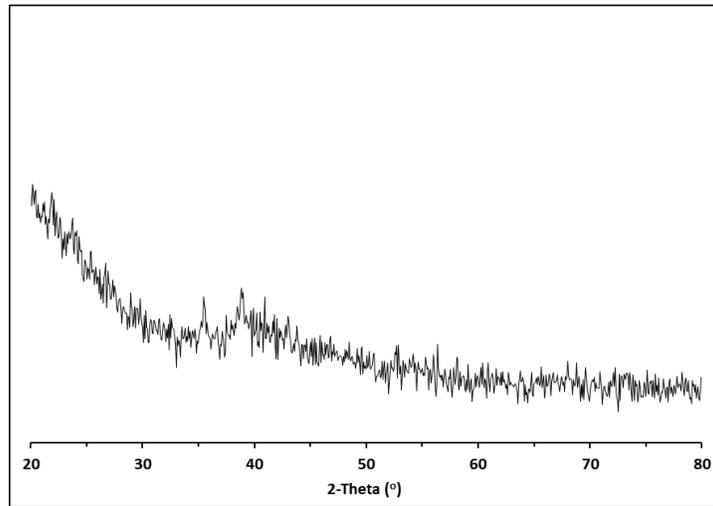
**(a) SEM image**



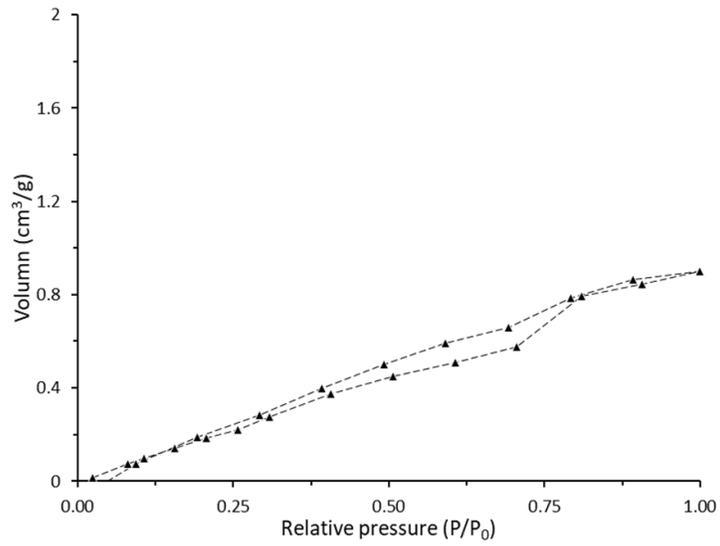
**(b) FTIR spectrum**



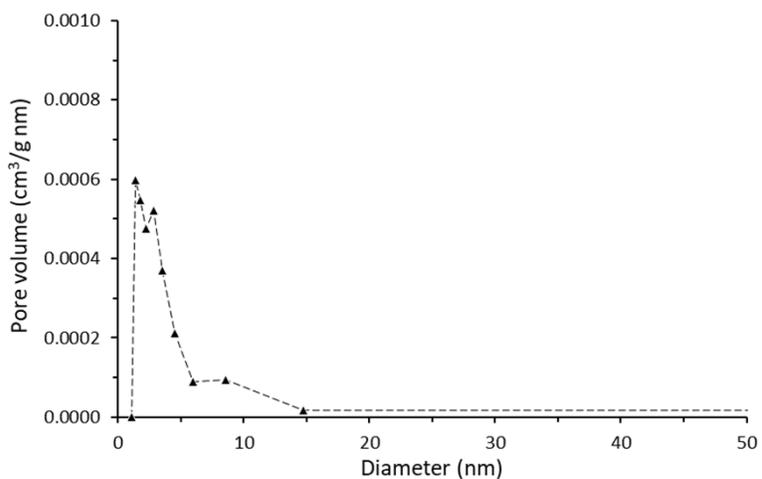
### (c) XRD pattern



### (d) Nitrogen adsorption/desorption isotherms



### (e) Pore size distribution

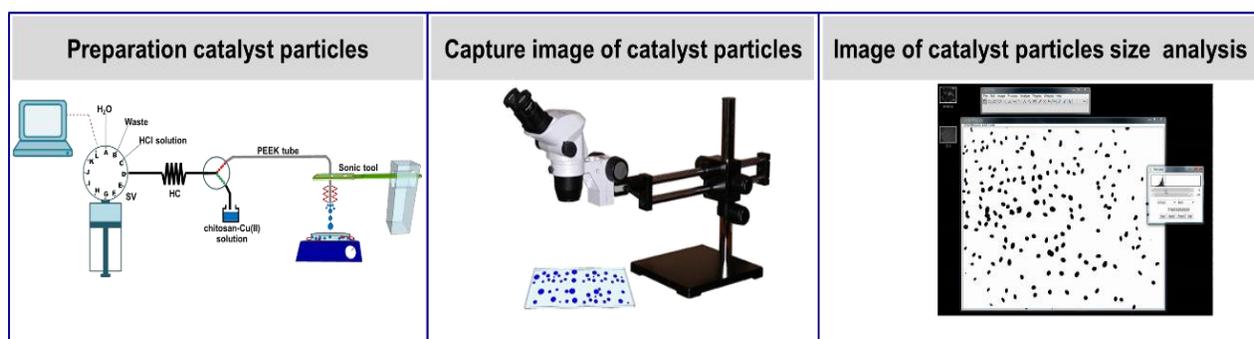


**Figure S1** Characterization of chitosan-Cu(II) catalyst particles: **(a)** SEM image; **(b)** FTIR spectrum of chitosan-Cu(II) catalyst showing bands at 3430, 2868, 2364, 1622, 1379, and 1097, 1013 and 599 cm<sup>-1</sup>, respectively; **(c)** XRD pattern,; **(d)** Nitrogen adsorption/desorption isotherms and **(e)** Pore size distribution.

## Supplementary Material B

### Measurement of particle size by ImageJ software: Effect of threshold number

Image J software is used for analyzing the size of objects on an image and measuring distance between objects. It is a free software for downloading from <http://rsb.info.nih.gov/ij/index.html>. Image J software is developed by National Institute of Mental Health (NIMH) in United State. It can measure objects in many units, such as square millimeter or number of pixels.



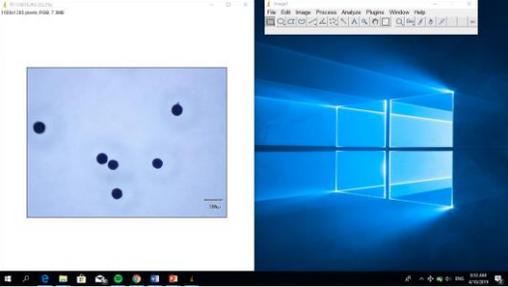
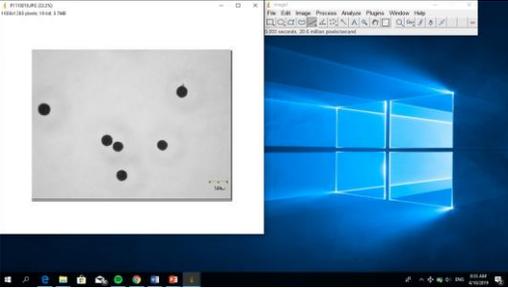
**Figure S2** Overview of steps including: (1) Preparation of CS-Cu(II) catalyst particles, (2) recording of particles image by an optical microscope, and (3) measurement of particles for size by Image J software.

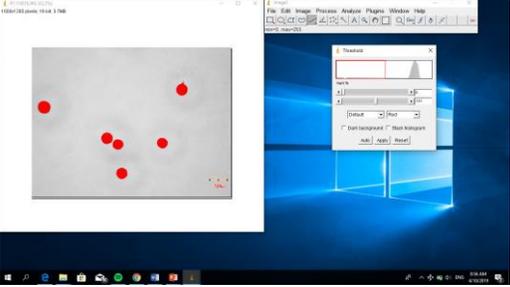
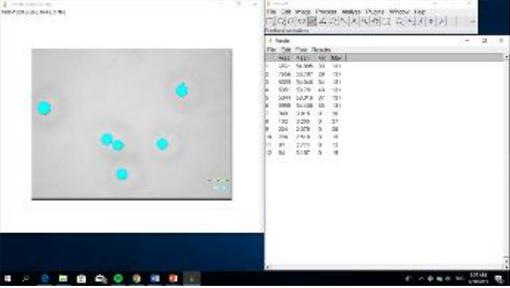
Figure S2 shows the schematic procedure for image analysis. This work uses ImageJ for measurement of particle size of the chitosan-Cu(II) catalyst particles. The operation steps for measurement are shown in Table S1.

Threshold adjustment is a software for segmenting the pixels of an object from the background. Advantages of this software are: 1. reduction of unnecessary pixels of the object, 2. converting image data into bitmap that it is easy to analyze or interpret.

To use the Image J program, the operator has to adjust some parameters before image analysis such as “threshold adjustment”.

**Table S1** Step-by-step procedure using Image J software for particle size analysis.

| Step | Description  | Screen capture   |
|------|--|--|
| 1    | <p>Opening a digital image file: Go to File</p> <p>► Open from menu bar to open a digital image of particles file, as shown in picture of the right.</p>   |    |
| 2    | <p>Setting scale bar in ImageJ: Select a straight line from the menu bar and draw a straight line from the known distance on your digital image file, as shown in picture of the right.</p>  |   |
| 3    | <p>Converting color digital image (RGB) into grey scale: If your digital image file is color image, it should be converted to grey image. Once the image is in grey scale “Image►Type►8-bit”, as shown in in picture of the right.</p> |  |

| Step | Description   | Screen capture  |
|------|---|---|
| 4    | <p>Setting a threshold of digital image file:</p> <p>Setting a threshold number to remove the background of image before image analysis (as seen in red color). A threshold number adjustment includes “Image ► Adjust ► Threshold, as shown in picture of the right.</p> |   |
| 5    | <p>Measuring area of objects: After finish setting parameter, go to “Analyze ► Analyze Particles”, as shown in Figure A.5. The output of software reports the area. The area data (blue color) was converted to diameter (see picture of the right).</p>                  |  |

**Reference:**

[1]. Chutimasakul, T.; Na Nakhonpanom, P.; Tirdtrakool, W.; Intanin, A.; Bunchuay, T.; Chantiwas, R.; Tantirungrotechai. J. Uniform Cu/chitosan beads as green and reusable catalyst for facile synthesis of imines via oxidative coupling reaction. *Unpublished results*. 2020.