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Anchored Ru Clusters on lignin/algae carbon aerogel as efficient bifunctional catalysts for water splitting

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Fig. S1. XRD patterns of composite polymer aerogels prepared with 0.02 g of  $RuCl_3 \cdot 3H_2O$ .



Fig. S2. TEM image of the Ru/SC-2.



**Fig. S3.** (a) Nitrogen (N<sub>2</sub>) adsorption-desorption isotherms at 77 K, (b) the pore size distribution of the P-Ru/SC-2.



Fig. S4. Full survey scan XPS spectrum of P-Ru/SC-2



Fig. S5. Raman spectrum of the untreated composite polymer aerogel.



**Fig. S6.** Cyclic voltammograms of (a) SC, (b) Ru/SC-2, and (c) P-Ru/SC-2 in 1 M KOH for HER with different scan rates from 20 to 100 mV s<sup>-1</sup>.



Fig. S7. Chronopotentiometry curve for HER of SC recorded at -20 mA cm<sup>-2</sup> in 1.0 M



Fig. S8. Chronopotentiometry curve for HER of Ru/SC-2 recorded at -20 mA cm<sup>-2</sup> in

1.0 M KOH.



Fig. S9. SEM images of P-Ru/SC-2 after the HER process.



Fig. S10. TEM and HRTEM images of P-Ru/SC-2 after the HER process.



**Fig. S11.** (a) XPS survey spectrum of P-Ru/SC-2 after the HER process. (b) High-resolution spectra of S 2p, respectively.