

The resulting samples were cleaned by deionized water until pH value ~ 7 and dried at 100 °C for 24 h. RH based activated carbon prepared this way was further implemented as electrode material in CDI using the technique described below.

Electrodes were prepared from three carbon materials: Norit DLC Super 30 (DLC Super 30), Kuraray YP 50F (KYP 50F) and rice husk based activated carbon (RH-AC). For each electrode preparation, 85wt% activated carbon (AC) was mixed with 5wt% carbon black (C65) and 10 wt% polytetrafluoroethene (PTFE). Carbon powders were blended with the binder in isopropanol used as the solvent. Next, they were rolled using a calendaring machine until achieving the demanded thickness of 500 μm . Materials were then dried under vacuum at 120 °C for 12 h.

2.2. Characterization

In order to investigate the morphology of samples, the scanning electron microscopy (SEM) combined with energy dispersive X-ray Spectroscopy (EDS) was conducted using the S-3400N SEM (Hitache).

The porous texture of carbons was characterized by nitrogen adsorption/desorption at -196 °C using the ASAP 2020 (Micromeritics). Prior to the analyses, the samples were degassed at 350 °C for 12 h under vacuum. The pore size distribution was determined based on the two-dimensional non-local density functional theory (2D-NLDFT) [22] model assuming an energetic heterogeneity of carbon pores. The average micropore size L_0 was determined from the Stoeckli equation [23].

All electrochemical experiments were carried out using a multi-channel potentiostat/galvanostat VMP3 (Biologic) using chronoamperometry with charging voltage up to 1.2 V, cyclic voltammetry (CV) at different scan rates and galvanostatic cycling with potential limitation (GCPL) with a potential limit up to 1.2 V and a constant current of 200 mA g^{-1} methods.

The specific capacitance (C_{sp} in F g^{-1}) of samples can be calculated from the CV measurement according to Eq. (1) [18]:

$$C_{sp} = \frac{\int idt}{m\Delta VS} \quad (1)$$

where i (A) is the current, s (V s^{-1}) is the scan rate, ΔV (V) is the voltage window, t (s) is the time and m (g) is the mass of the electrode.

2.3. CDI measurement

A CDI installation included influent and effluent reservoirs, peristaltic pump, conductivity meter (CPC-501), CDI module, pH meter (Elmeiron) and potentiostat-galvanostat. The relationship between conductivity and molar concentration was obtained according to the calibration curve. Ions were electrosorbed from the solution by applying the direct voltage of 1.2 V between pair of electrodes. Solutions of 5, 10, 50 and 100 mmol L^{-1} NaCl (Sigma Chempur) were prepared by measuring NaCl crystals on an analytical balance and diluting in a volumetric flask. The flow rate of the peristaltic pump was equal to 5 mL/min.

The equilibrium electrosorption capacity (S , mg g^{-1}) per mass of electrode was defined as following Eq. (2) [19]:

$$S = \frac{(C_0 - C_e)V}{M} \quad (2)$$

where C_0 and C_e represent initial and equilibrium concentrations of NaCl solution (mg L^{-1}), respectively, V is the volume of solution (L), and M is the mass of the electrodes (g).

3. Results and discussion

The microstructure and morphology of the ACs obtained on the basis of RH were investigated using the SEM analyses, while the micrographs are shown in Fig. 1a on which one can see that the sample of RH-AC is irregularly granular. SEM images represented in Fig. 1b,c,d demonstrate morphological features of the surface texture of RH-AC representing the AC obtained by carbonization and activation of RH. The sample is characterized by a porous structure with macropores of various diameters from 10 μm and below. The material of the home-made AC is represented by the existence of macroscopic ensembles of ultrafine particles with the size from 50 to 300 μm . It is noted that the surface morphology is loose, formed by a system of pores and channels formed by the nature to ensure plant life.

Application of potassium hydroxide for the chemical activation of preliminary carbonized RH resulted in the production of ACs with an outstanding porous structure, openwork surface and texture morphology, as can be seen from Fig. 1b,c,d. The general appearance of the material has common morphological features, such as the channel