to increase in the wetted surface area, enhances the efficiency of CDI process. All carbon electrodes exhibited their capability to slightly adsorb ions on the electrode surface. The percentage of salt removal (0.1 mol L^{-1} NaCl, MgCl and KCl) was examined in [8]. When the potentials of 1.0, 2.0, and 3.0 V were applied to the CDI cell, the result showed that a 0.1 mol L^{-1} KCl solution had a greater percentage of salt removal than the solutions of NaCl and MgCl having the same concentration of ions dissolved. The percentage of salt removal from KCl was achieved at 55% for 3.0 V, while for NaCl and MgCl 20 and 30% were obtained, respectively [7–8].

A novel liquid binder used in the preparation of electrodes from activated carbon for application in CDI process was synthesized on a basis of acrylic acid and azodiisobutyronitrile [9]. As a result, its wettability was significantly improved, and the specific capacitance was increased by a factor of 8. The optimization showed that electrodes with a mass fraction of activated carbon of 35 wt% had the best CDI performance.

Up-to-date progress on the fabrication of electrode materials applicable in CDI process was reviewed in [10]. Herein, the fundamental principal (e.g. EDL theory and adsorption isotherms) as well as process factors (e.g. pore distribution, potential, salt type and concentration) of CDI performance were discussed. It was then followed by in-depth discussion and comparison on properties and fabrication technique of different electrodes, including carbon aerogel, activated carbon, carbon nanotubes, graphene and ordered mesoporous carbon. Novel nanomaterials such as graphene and CNTs are attracting increased attention in this area due to their extremely high specific surface area and electrical conductivity. It is noteworthy that polyaniline (PANI) as conductive polymer has a great potential for application in the CDI processes as electrode-enhancing materials. It was envisaged that large scale PANI-assisted CDI electrode fabrication can be plausible due to its low cost, mechanical flexibility and good electrical properties [10].

Carbon electrodes for the desalination system have been successfully synthesized with and / or without modified activated carbon by chemical activation using HNO_3. The results showed that the percentage of salt removal using the carbon electrodes with a modified activated carbon is higher than the carbon electrodes without modification of activated carbon, whilst the reduction level is equal to 55.7 and 24.8%, respectively [11].

Application in the CDI process of carbide-derived carbon (CDC) representing porous material with well-defined and tunable pore sizes in the sub-nanometer range was reported in [12]. Comparison of the electrode composites based on CDC with composites based on activated carbon showed that the former has a significantly higher salt adsorption capacity in the relevant cell voltage window of 1.2−1.4 V [12]. The measured adsorption capacity for four materials tested negatively correlates with known indicators for the pore structure of carbon powders, such as the total pore volume and BET area. But at the same time, it positively correlates with pore volumes with sizes <1 nm, which indicates the relevance of these subnanometer pores for ion adsorption. The charge efficiency, which is the ratio of the equilibrium salt adsorption to charge, does not depend much on the type of material, which indicates that materials that have been identified for high charge storage capacity can also be very suitable for CDI. For CDI, the most promising materials for electrodes are those which have a high specific surface area, a large number of subnanometric pores, good electrical conductivity and low cost [13–19]. Due to these properties, nanoporous carbons have attracted the attention of researchers around the world [20–22].

Porous carbon materials utilized in this study include two commercially available activated carbon powders, particularly the Norit DLC Super 30 (Calgon Carbon) and Kuraray YP 50F (Cabot). The home-made activated carbons were synthesized from rice husk (RH) through its carbonization and subsequent chemical activation processes. The objective of this work was to determine the most optimal conditions of the desalination process while electrosorbing in porous electrodes. For this reason, the various electrode materials and experimental parameters were investigated.

2. Experimental

2.1. Preparation of electrode materials

The rice husk (RH) was derived from local farms of Almaty region (Kazakhstan) and subjected for cleaning and drying to constant mass followed by carbonization at 500 °C ±10 °C under nitrogen atmosphere for 1 h. Chemical activation was carried out at 800 °C ±10 °C under nitrogen atmosphere for 1 h. Potassium hydroxide was used as an activating agent, while the mass ratio of precursor to KOH equal to 1:4 was applied.