BAB 5

KESIMPULAN DAN SARAN

5.1 Kesimpulan

Dari hasil penelitian yang telah dilakukan, terdapat beberapa kesimpulan yang dapat diambil yaitu:

1. *N-doped hard carbon* dengan proses karbonisasi hidrotermal dengan variasi rasio massa 1:1 dan 1:3 memiliki *yield* produk secara berurutan sebesar 3,3301 dan 5,008 %-wt. Sedangkan *yield* produk *N-doped hard carbon* yang dihasilkan melalui proses karbonisasi langsung dengan variasi rasio massa 1:1 dan 1:3 secara berurutan adalah 27,1225 dan 32,2125 %-wt. Sampel dengan perlakuan karbonisasi langsung dengan jumlah urea yang banyak dapat menghasilkan *yield* perolehan yang tinggi.
2. Melalui karakterisasi XRD, sampel *N-doped hard carbon* yang dihasilkan baik dengan karbonisasi hidrotermal maupun langsung memiliki struktur yang *amorphous*. Namun, sampel NHTT-900-3 memiliki struktur yang paling *amorphous* dengan persen *amourphous* 75,7 % dan kristal 24,3 %. Selain itu, keempat sampel *N-doped hard carbon* mempunyai *interlayer spacing* (d_{002}) diantara 0,369 – 0,3846 nm sehingga sudah tergolong *hard carbon*, tetapi sampel NHTC-900-3 memiliki *interlayer spacing* yang paling besar yaitu 0,3846 nm. Proses karbonisasi hidrotermal dan kandungan urea yang lebih banyak dapat membuat *interlayer spacing* sampel menjadi lebih besar sehingga memberikan potensi kapasitas penyimpanan ion sodium pada baterai ion sodium lebih besar.
3. Melalui karakterisasi EDX, kandungan nitrogen yang ada pada sampel NHTT-900-1, NHTT-900-3, NHTC-900-1, dan NHTC-900-3 secara berurutan adalah 2,66 %-wt; 6,09 %-wt; 4,65 %-wt; dan 8,77 %-wt. Sampel dengan proses karbonisasi hidrotermal dengan kandungan urea yang lebih banyak dapat memberikan persen komposisi berat nitrogen yang paling besar sehingga dapat diketahui bahwa proses karbonisasi hidrotermal dapat melakukan penetrasian unsur nitrogen dengan lebih baik apabila dibandingkan dengan proses karbonisasi langsung.
4. Melalui karakterisasi spektroskopi Raman, didapatkan nilai rasio intensitas I_D/I_G pada sampel NHTT-900-1, NHTT-900-3, NHTC-900-1, dan NHTC-900-3 secara

berurutan adalah 1,06; 1,17; 1,23; dan 1,34 cm^{-1}. Sampel dengan proses karbonisasi hidrotermal dengan kandungan urea yang lebih banyak dapat memberikan tingkat kerusakan atau ketidakteraturan pada sampel paling tinggi, sehingga dapat memberikan potensi ruang penyimpanan ion sodium pada anoda baterai lebih besar.

5.2 Saran

Saran yang dapat dipertimbangkan untuk kepentingan pengembangan penelitian selanjutnya adalah sebagai berikut:

1. Perlu dilakukan variasi temperatur pada saat proses pirolisis di dalam *furnace* pada sampel agar dapat diketahui temperatur optimal dalam produksi *N-doped hard carbon*.
2. Perlu dilakukan variasi waktu pada proses *pre-treatment* dan dilanjutkan dengan analisis dengan *Fourier Transform Infrared Spectroscopy* (FTIR) untuk mengetahui keberadaan nitrogen setelah proses *pre-treatment*.
3. Perlu dilakukannya pengukuran pH dan analisis lanjutan menggunakan alat *High Performance Liquid Chromatography* (HPLC) pada air cucian *hydrochar* untuk memastikan bahwa tidak ada lagi produk samping yang terbawa pada sampel *N-doped hard carbon*.
4. Perlu dilakukan karakterisasi SEM dan XRD pada sampel setelah tahap *pre-treatment* dan karbonisasi hidrotermal agar dapat dibandingkan hasilnya baik secara struktur dan morfologi dengan *N-doped hard carbon* yang dihasilkan.
5. Diperlukan pengujian terhadap hasil *N-doped hard carbon* yang telah dibuat untuk dijadikan sebagai bahan anoda pada baterai ion sodium, sehingga dapat dibandingkan secara langsung perbedaan kapasitas penyimpanan baterai serta efisiensi baterai ion sodium yang menggunakan anoda berbahan baku *N-doped hard carbon* dengan karbon-karbon lainnya.

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