

Review on- Study of characteristics of low cost activated carbon

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Abstract

This paper reviews on study of characteristics of low cost activated carbon. Different researchers focus on physico-chemical characterization of activated from prepared from waste and low cost materials using XRD, SEM, FT-IR and TGA.techniques. physical properties such as bulk density, moisture content, volatile matter content, ash content, and surface area ,porosity apparent density acid soluble matter, fixed carbon, pH, iodine number and porosity were studied and analysed in detail by different authors

Keywords— Activated carbon, Activation methods, Bulk density, Surface area.

I. INTRODUCTION

Activated carbons having high specific porosity, high surface areas are extremely versatile adsorbents of major industrial significance. The adsorption capacity of activated carbon is linked to their large surface area, a high micro porosity and a high degree of surface reactivity [1,2] carbon can be synthesized by two methods, chemical and physical activation. In Chemical activation the starting materials is impregnated with a strong dehydrating agent and then followed by Pyrolysis at high temperature to prepare activated carbon. Physical activation method consists of carbonization of the precursor material in an inert atmosphere and gasification of the resulting char in the presence of steam, carbon dioxide or air.[3]. Activated Carbons are high surface area and porous carbon has been widely used as an adsorbent for separation, purification, decolorization and deodorization of vegetable oils and fats, water purification and pollution treatment, air and gas purification and the food and pharmaceutical industries. Activated carbon is widely used for the purpose due to the large surface area available for adsorption or chemical reactions as a result of its high degree of micro porosity[4,5] The importance and relevance of activated carbon to an ever growing society cannot be overemphasized considering its enormous uses[17] Characteristics of AC depend on the physical and chemical properties of the raw materials as well as method of activation[20] In chemical activation process, the precursor is mixed with a chemical such as sulphate salts, chloride salts, KOH, HCl, ZnCl₂, H₂SO₄, H₃PO₄ carbonized and washed to produce the

activated carbon.[23] Activated carbons are widely used as adsorbents. Due to high production cost, the commercialized activated carbons are expensive and usually not economical for large scale applications.

II. REVIEW ON CHARACTERISTICS OF ACTVATED CARBON

B. Sivakumar et.al Preparation and characterization of activated carbon prepared from balsamodendron caudatum wood waste through various activation processes. They were prepared activated carbon from wood waste by various chemical processes. The scanning electron microscopy were used for study of morphology and the surface functional group was investigated by Fourier transformation infrared spectroscopy techniques. Physico-Chemical characteristics such as bulk density, moisture content, ash content, matter soluble in water, matter soluble in acid, pH, iodine number, conductivity, porosity ,yield percentage and surface area was carried out to assess the suitability of the carbon as absorbent[1].Preparation and Characterization of Activated Carbon from Lapsi Seed Stone by Chemical Activation with Potassium Hydroxide was studied by Sahira Joshi and Bhadra Pokharel .Prepared activated carbon was characterized by pH, moisture content, Fourier transform-infrared spectroscopy, scanning electron microscopy methylene blue and iodine number[2].Activated Charcoal preparation, characterization and Applications was studied by Mohammad Khah and R. Ansari[3].Hassan et.al Synthesis and Characterization of Activated Carbon from Saudi Arabian Dates Tree's Fronds Wastes They were studied characteristics of activated carbons by using techniques like infrared spectroscopy transmission electron microscopy , scanning electron microscopy , X-ray diffraction, optical microscopy , apparent surface area estimation by nitrogen adsorption iodine number and ion-exchange capacity[4].

Rhoda Habor et.al Production of Activated Carbon and Characterization from Snail Shell Waste.They were studied characteristics of produced activated carbon such as PH,Pore Volume and Porosity, Ash Content, Determination of Moisture Content, Bulk Density and the activated carbon prepared was characterized, showing effect of temperature on ash content, pore volume and porosity[5].Dipa Das et.al.

Preparation of Activated Carbon from Green Coconut Shell and its Characterization. Activated carbon was prepared from green coconut shells by chemical activation method. And it was then characterized by XRD, SEM, FT-IR and TGA. Different physical properties such as bulk density, moisture content, volatile matter content, ash content, and surface area and porosity were also determined [6]. Hariprasad et.al. Preparation and characterization of activated carbon from rice husk. The surface of activated carbon prepared has been analysed using SEM, in order to identify the functional group responsible for adsorption Fourier transform infrared spectroscopy analysis was carried out. BET surface of both samples were identified using nitrogen adsorption-desorption isotherms, along with this pore size, pore volume created in samples were also identified [7].

M. Sivachidambaram et.al. Preparation and characterization of activated carbon derived from *Borassus flabellifer* flower as electrode material for super capacitor applications. There were used *Borassus flabellifer* flower for the preparation of activated carbon activated by using H_3PO_4 as an activating agent. Scanning electron microscopy-ray analysis and Fourier-infrared spectroscopy analysis were used for activated sample analysis [8]. S. Manocha et.al Preparation and Characterization of Activated Carbon from Demineralized Tyre Char. Authors were investigated use of activated carbon for the wastewater treatment and in the recovery of gases and purification of gas mixtures. They were used char either as low-grade reinforcing filler or as activated carbon [9]. Characterization of activated carbon and application of copper removal from drinking water was studied by Yasemen Kutmen. Authors were remove copper ions from aqueous solution by adsorption using Granular activated carbon which was characterized using nitrogen porosimetry, pH titration, Boehm's titration, mercury porosimetry, FTIR and scanning electron microscope measurements [10].

A. Agalya et.al. preparation and characterization of activated carbon from *Euphorbia tirucalli* wood for the removal of textile dyes from waste water. They were used renewable lignocellulosic material *Euphorbia Tirucalli* L wood for the production of activated carbon by physical and chemical activation using different activating agents like H_2SO_4 , H_3PO_4 , KOH and $ZnCl_2$. The activated carbon was characterized by pH, ash content, volatile matter, Porosity, conductivity, bulk density, specific gravity, iodine number and adsorption of methylene blue [11]. Jalel Ben Nasr et.al. Characterization of activated carbon Prepared from sludge paper for methylene blue adsorption. They were prepared activated carbon prepared from paper sludge which was activated by using K_2CO_3 . The adsorption behaviour of Methylene Blue dye from aqueous solution onto activated carbon was investigated as a

function of equilibrium time, pH and concentration [12].

Preparation and characterization of activated carbon from bio-diesel by-products (*Jatropha seedcake*) by steam activation was investigated by M. S. Islam. Authors were prepared activated carbon using bio-diesel waste (*Jatropha seedcake*) by conventional carbonization followed by steam activation. Preliminary tests were conducted to investigate the influences of different operating parameters, such as initial material size, pyrolysis temperature and hold time on the properties of pyrolyzed chars [13]. Riry Wirasmita et.al Preparation and characterization of activated carbon from oil palm empty fruit bunch wastes using zinc chloride. Authors were used an oil palm empty fruit bunch for the production of activated carbon followed by chemical activation. The proximate analysis including moisture content, ash content, bulk density, pH, and pH at zero charge was conducted to identify the physicochemical properties of the adsorbent [14]. Amjad H. et.al. characterization of activated carbon prepared from a single cultivar of Jordanian Olive stones by chemical and physicochemical techniques. Investigators were used olive stones from Jordan for the preparation of activated carbon. The preparation conditions were varied to study their effects on the surface area, porosity, Morphology, functionality and crystal structure. They were studied variables like time of carbonization, time of activation, activating agent, particle size, sample pre-drying, hydrogen peroxide post treatment and the effect of the activation process [15].

Chubaakum et.al. Synthesis and Characterization of Activated Carbon from the Biowaste of the Plant *Manihot Esculenta*. Authors were prepared activated carbon from biowaste material of the plant *Manihot esculenta* followed by activation using HNO_3 . Authors were analysed physical parameters such as apparent density, ash content, volatile matter, water soluble matter, acid soluble matter, fixed carbon, pH, iodine number and porosity. Energy-Dispersive X-Ray and Scanning Electron Microscope techniques were used for elemental analysis [16]. Production and characterization of activated carbon from selected local raw materials was studied by Yusufu and Igbabul. Investigators were used bone, wood and coconut shell for the preparation of activated carbons. Micrometric surface area analyzer were used for surface area and porosity characterization and Barrett, Joyner, Halenda method was employed for the evaluation of the pore size distribution [17]. Preparation and characterization of activated carbon from rubber based shell by chemical activation was investigated by Azry Borhan and Ahmad Fikree Kamil. Authors were used rubber based shell for the preparation of activated carbon. Nitrogen adsorption theorem and scanning

electron microscope instruments were used for analysis of surface area, pore volume, diameter of activated carbon [18]. Preparation and Characterization of Activated Carbon from Reedy Grass Leaves in a Two- Step Activation was evaluated by Xu Jianzhong and Chen Lingzhi. Authors used Reedy Grass Leaves for the preparation of activated carbon. FT-IR method was used for determination of surface chemical characteristics of activated carbons. BET surface area, pore volume and pore size of activated carbons were characterized by N_2 adsorption isotherms. The microstructure of the produced activated carbons was examined by scanning electron microscopy. Thermal gravimetry analysis of raw material was carried out [19].

Verla et.al Preparation and characterization of activated carbon from pumpkin seed shell. Authors used pumpkin seed shell for the preparation of activated carbon followed by chemical activation. Characteristics of the activated carbons were determined using standard methods [20]. Olalekan et.al. Preparation and Characterization of Activated Carbon – nFe_3O_4 , Activated Carbon – $nSiO_2$ and Activated Carbon – $nZnO$ Hybrid Materials. Surface area and porosity, ash content, pH, and point of zero charge were evaluated and the material was characterized by scanning and transmission electron microscopy, x-ray diffraction, and Fourier transform infra-red spectroscopy [21]. Jafar Ahamed and R. Ahamad were investigated Preparation and Characterization of Activated Carbon from the Prosopis juliflora Plant. Authors studied physicochemical characteristics such as bulk density, moisture content, ash content, carbon content, matter soluble in water, matter pH, iron content, surface area, pore specific volume and surface morphology [22]. J. Raffiea et.al. Preparation and characterization of activated carbon from Thevetia peruviana for the removal of dyes from textile waste water. Authors prepared activated carbon from Thevetia peruviana by physical and chemical processes such as direct pyrolysis, dolomite process. They investigated characteristics such as moisture content, volatile matter, pH, conductivity, bulk density, specific gravity, porosity, methylene blue number, iodine number and [23]. R. Malik et. Physicochemical and surface characterization of adsorbent from groundnut shell by $ZnCl_2$ activation and its ability to adsorb colour. Authors were examined changes in surface morphology of activated carbon before and after activation by using scanning electron microscopy and FTIR spectroscopy were used for surface modifications through chemical changes [24]. R. Malik et.al. Physicochemical and surface characterization of adsorbent from groundnut shell by $ZnCl_2$ activation and its ability to adsorb colour. Investigators used FTIR, and nitrogen adsorption methods for activated surface analysis [25]. A. Rahman et.al.

Preparation and characterization of activated charcoal as an adsorbent. Adsorption of oxalic acid and maleic acid from their aqueous solution using charcoal was studied [26].

P. Sugumaran et.al. Production and Characterization of Activated Carbon from Banana Empty Fruit Bunch and Delonix regia Fruit Pod. Investigators used banana empty fruit bunch and Delonix regia fruit pod for preparation of activated carbon through single step chemical activation process. Authors studied pH, electrical conductivity and bulk density of the activated samples. FT-IR analysis BET surface area [27]. Allwar et.al. Textural Characteristics of Activated Carbons Prepared from Oil Palm Shells Activated with $ZnCl_2$ and Pyrolysis under Nitrogen and Carbon Dioxide. Authors prepared activated carbon prepared from oil palm shells. The structural morphology and composition of activated carbons were evaluated by SEM-EDX. The micropore volume and pore diameter were evaluated by the D-R and D-A methods [29]. Physicochemical characteristics of activated charcoal derived from melon seed husk was investigated by Madu and Lajide. Investigators used melon seed husk for the preparation of activated carbon. Authors characterized powder activated carbon for the particle size, pH, bulk density, iodine adsorption number, pore volume, porosity and moisture content [30]. Y.J. Tham et.al Physical Characteristics of Activated Carbon Derived from Durian Shell. Authors used Durian shell for the preparation of activated carbon and studied characteristics like surface area and pore structure. They were observed that the highest BET surface area was $1404 \text{ m}^2/\text{g}$ [31].

III. CONCLUSION

Activated carbon is one of the good adsorbent. In present paper it is concluded that activated carbon can be easily prepared from waste and low cost materials. Different researchers used different activation processes for active and having high porosity activated carbon. Many authors investigated that activated carbons prepared by physical activation are better adsorbents than prepared by chemical activation. Activated carbon is characterized by such as Iodine number, methylene blue number, SEM image, FTIR spectroscopy for determining different parameters such as bulk density, moisture content, volatile matter content, ash content, and surface area and porosity by pH, ash content, volatile matter, Porosity, conductivity, bulk density, specific gravity, iodine number

REFERENCES

- [1] B. Sivakumar, C. Kannan, S. Karthikeyan, "Preparation and characterization of activated carbon prepared from balsamodendron caudatum wood waste through various activation processes", Rasayan journal of chemical engineering, Vol. 5, No.3, pp.321-327, 2012.

- [2] Sahira Joshi, Bhadra Prasad Pokharel, "Preparation and Characterization of Activated Carbon from Lapsi Seed Stone by Chemical Activation with Potassium Hydroxide", Journal of the Institute of Engineering, Vol. 9, No. 1, pp. 79–88.
- [3] A. Mohammad-Khah and R. Ansari, "Activated Charcoal: Preparation, characterization and Applications", International Journal of ChemTech Research, Vol.1, No.4, pp 859-864, 2009.
- [4] Hassan M. Al-Swaidan and Ashfaq Ahmad, "Synthesis and Characterization of Activated Carbon from Saudi Arabian Dates Tree's Fronds Wastes", 3rd International Conference on Chemical, Biological and Environmental Engineering, vol.20,2011
- [5] Rhoda Habor Gumus, Ideyone Okpeku, "Production of Activated Carbon and Characterization from Snail" Advances in Chemical Engineering and Science, 5, pp.51-61, 2015.
- [6] Dipa Da, Debi Prasad Samal, Meikap, "Preparation of Activated Carbon from Green Coconut Shell and its Characterization", J Chem Eng Process Technol, 2015.
- [7] Hariprasad.p, Rajeshwari sivaraj, Anizcu "Preparation and characterization of activated carbon from rice husk", International Research Journal of Engineering and Technology, Volume: 03 Issue: 04, Apr-2016.
- [8] M. Sivachidambaram, J. Judith Vijayaa, L. John Kennedyb, R. Jothira malingam Hamad Al-Lohedanc, Murugan A. Munusamyd, E. Elanthamilane, J. Princy Merline, "Preparation and characterization of activated carbon derived from *Borassus flabellifer* flower as electrode material for super capacitor application", New Journal of Chemistry, pp 1-28, 2017.
- [9] S. Manocha, Guddu R Prasad, Parth. Joshi, Ranjitsingh S. Zala, Siddharth S.Gokhale and L. M. Manocha, "Preparation and Characterization of Activated Carbon from Demineralized Tyre Char", pp. 109-112, 2013.
- [10] Yasemen Kutmen Kalpakli, Ikbak Koyuncu, "Characterization of activated carbon and application of copper removal from drinking water", Annali di Chimica, pp.1291-1302, 2007.
- [11] A. Agalya, P. N. Palanisamy, and P. Sivakumar, "Preparation and characterization of activated carbon from euphorbia tirucallil wood for the removal of textile dyes from waste water", Int. J. Chem. Science, 11(2), pp.957-967, 2013.
- [12] Jalel Ben Nasr, Nouredine Hamdi, Foued Elhalouani "Characterization of activated carbon Prepared from sludge paper for methylene blue adsorption", Journal of Materials and Environmental Sciences 8 (6), pp. 1960-1967, 2017.
- [13] M. S. Islam, M. A. Rouf, S. Fujimoto and T. Minowab, "Preparation and characterization of activated carbon from bio-diesel by-products by steam activation", Bangladesh J. Sci. Ind. Res. 47(3), pp.257-264, 2012.
- [14] Riry Wirasmita, Tony Hadibarata, Abdulla Rahim, Mohd Yusoff, Zainab, Mat Lazim "Preparation and characterization of activated carbon from oil palm empty fruit bunch wastes using zinc chloride", Journal Sciences & Engineering, pp.77–81, 2015.
- [15] Amjad H. El-Sheikh, Alan P. Newman, Hafid K. Al Daffae, SukiPhull, Neil Cresswell, "Characterization of activated carbon prepared from a single cultivar of Jordanian Olive stones by chemical and physicochemical techniques", J. Anal. Appl. Pyrolysis, pp.151–164, 2004.
- [16] Chubaakum Pongener, Daniel Kibami, Kaza S.Rao Rajib L.Goswamee, Dipak sinha, "Synthesis and Characterization of Activated Carbon from the Biowaste of the Plant *Manihot Esculenta*", Chem Sci Trans., 4(1), pp.59-68, 2015.
- [17] Yusufu M. Ariahu C. and Igbabul B, "Production and characterization of activated carbon from selected local raw materials", African Journal of Pure and Applied Chemistry Vol. 6(9), pp. 123-131, 2012.
- [18] Azry Borhan and Ahmad Fikree Kamil, "Preparation and characterization of activated carbon from rubber based shell by chemical activation", Journal of Applied Sciences, pp.1124-1129, 2012.
- [19] Xu Jianzhong, Chen Lingzhi, Feng Xiaojie, "Preparation and Characterization of Activated Carbon from Reed Grass Leaves in a Two- Step Activation", International Conference on Material and Environmental Engineering, pp.99-102, 2014.
- [20] Verla, M. Horsfall, E.N Verla, A.I. Spiff, O.A. Ekpete, "Preparation and characterization of activated carbon from pumpkin seed shell", Asian Journal of Natural and Applied Sciences, vol.1.no.3, pp 39-50, 2012.
- [21] Olalekan S. Fatoki, Olushola S. Ayanda, Folahan A. Adekola, Bhekumusa J. Kimba, Beatrice O. Opeolu, "Preparation and Characterization of Activated Carbon – nFe₃O₄, Activated Carbon – nSiO₂ and Activated Carbon – nZnO Hybrid Materials", pp 178-191.
- [22] A. Jafar Ahamed and K.R.Ahmad "Preparation and Characterization of Activated Carbon from the Prosopis juliflora Plant", Asian Journal of Chemistry, Vol. 20, No. 3, pp.1702-1706, 2008.
- [23] J. Raffiea Baseri, P. N. Palanisamy and P. Sivakumar, "Preparation and characterization of activated carbon from *Thevetia peruviana* for the removal of dyes from textile waste water", Advances in Applied Science Research, pp.377-383, 2012.
- [24] R.Malik, D.S.Ramteke and S.R.Wate, "Physicochemical and surface characterization of adsorbent from groundnut shell by ZnCl₂ activation and its ability to adsorb colour", Indian journal of chemical technology, vol.13, pp.319-328, 2006.
- [25] Virote Boonamnuyvitaya, Chaiyan Chaiya, Wiwut Tanthapanichakoon, "The preparation and characterization of activated carbon from coffee residue", Journal of chemical engineering of Japan, vol 37.no12, pp.1504-1512, 2004.
- [26] A.Rahman, Asadullah, M.Haque, A. Motin, B.Sultan, K.Azad, "Preparation and characterization of activated charcoal as an adsorbent", Journal of surface science technol, vol 22, pp. 133-140, 2006.
- [27] P. Sugumaran, V. Priya Susan, P. Ravichandran and S. Seshadri, "Production and Characterization of Activated Carbon from Banana Empty Fruit Bunch and Delonix regia Fruit Pod", Journal of Sustainable Energy & Environment, pp 125-132, 2012.
- [28] Allwar, Ahmad Bin Md Noor and Mohd Asri Bin Mohd Nawi, "Textural Characteristics of Activated Carbons Prepared from Oil Palm Shells Activated with ZnCl₂ and Pyrolysis Under Nitrogen and Carbon Dioxide", Journal of Physical Science, Vol. 19(2), pp.93–104, 2008.
- [29] Junichi Miyamoto, Hirofumi Kanoh, Katsumi Kaneko, "Pore structures and adsorption characteristics of activated carbon fibres having both micro and mesopores", Am. Chem. Soc., Div. Fuel Chem, pp.1-3, 2005.
- [30] Madu P. C. and Lajide L, "Physicochemical characteristics of activated charcoal derived from melon seed husk", Journal of Chemical and Pharmaceutical Research, pp. 94-98, 2013.
- [31] Y.J. Tham, Puziah Abdullatif, A.M.Abdullah and Y.H.Taufiq, "Physical Characteristics of Activated Carbon Derived from Durian Shell", Asian Journal of Chemistry Vol. 22, No. 1 pp.772-780, 2010.