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Utilization of Micro Fibrous Carbon Matrix from Tannery Solid Waste for Making Pavement Materials

K. Patchai Murugan[a], S. Swarnalatha[a,*], G. Sekaran[b,*]

[a] *Department of Environmental Technology, Central Leather Research Institute, Adyar, Chennai, Tamil Nadu, India*
[b] *Institution, City, Country*

Abstract

Tannery buffing dust (TBD) contains high amount of potential chemicals including Cr (III) besides carcinogenic organic compounds. The Cr (III) present in TBD can be thermodynamically feasible to convert into carcinogenic Cr (VI). The obnoxious gases such as oxides of sulphur, ammonia and other volatile organic compounds are emitted from tannery buffing dust during the thermal decomposition. Pyrolysis of a chromium-tanned buffing dust under controlled O_2 atmosphere has been carried out in a thermal reactor to eliminate the environmental burden of these toxic pollutants. The effect of process variables, such as temperature, pyrolysis time, and heating rate on the pyrolytic product distribution was studied. Flash pyrolysis upto 550 °C and slow pyrolysis from 550 to 800 °C with applying O_2at the rate of 1LPM in the temperature range between 700 and 800 °C were studied. The pyrolysed tannery buffing dust was characterized by XRD, SEM, FTIR, TGA and CHNS analyzer. The pyrolysed TBD was effectively solidified / stabilized using Portland cement and also bitumen mixture. Unconfined compressive strength of the blocks was in the range of 16-99KN. The leachability of the stabilization of Cr (III) in the solidified matrix was confirmed through XRD.

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Keywords: Buffing dust – pyrolysis – Chromium (III) – solidified blocks – Portland cement;

Introduction

Leather industry in the developing countries is facing lots of solid wastes problem. Out of 1000 kg of raw hide, nearly 700-750 kg is generated as solid wastes in leather processing. Only 250-300 kg of the raw material is

* Corresponding author.
E-mail address: ganesansekaran@gmail.com; swarnavinayak2009@gmail.com

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converted into leather. Tannery generates huge amount of solid waste as follows: fleshing, 50-60%; chrome shaving/chrome splits/buffing dust, 35-40%; skin trimmings, 5-7%; and hair, 2-5% [J Kanagaraj, et al 2006]. Different forms of waste in quantity and quality, which emerge during transformation of hides and skins to leather, have negative impacts on the environment. The methods of disposing Tannery Buffing Dust (TBD) are land co-disposal and thermal incineration. Land co-disposal method is not recommended for the reasons of overall high pollution emissions and low energy recovery. The thermal treatment method can be preferred for its reduction in volume of solid waste to be disposed of in the useful way. The thermal treatment of solid wastes involves incineration, gasification and pyrolysis as the means of disposal, to recover energy from the waste. The investment cost for gasification is higher than thermal incineration and land co-disposal methods. But, cost of the thermal incineration/pyrolysis process is only about 1/6th of the total cost for the land filling scenario [G. Assefa, et al 2005]. And also the available landfill sites rapidly reach their total capacity and the authorization for new sites becomes difficult [D.W. Kirk, et al 2002]. So, the thermal incineration/pyrolysis is considered as the cheapest alternative and attractive method for its simultaneous energy production and volume reduction of solid waste. The pyrolysis of tannery solid waste, particularly Tannery buffing dust, needs a special attention on the issues such as release of toxic chromium (VI), halogenated organic compounds, polyaromatic hydrocarbons etc. into the environment [S. Swarnalatha, et al, 2008]. Although the energetic efficiency in pyrolysis is lower than in combustion, it can convert wastes into gas, liquid, and solid fractions with different applications. Solidification/stabilization is another technique for disposal of solid waste containing heavy metals providing high level protection of environment. Stabilization involves mixing wastes with binding agents like clay [M.A. Abreu, et al 2009], ceramics [T. Basegio, et al 2002], alumina [T.Basegio, et al 2006], asphalt, cement clay [S.M.Abtahi, et al 2010] etc. Carbon Nano fibres (CNF) attracted considerable attention owing to its unique mechanical, structural, and catalytic properties, excellent electrical conductivity and chemical stability, and tunable surface functionalities, resulting in a wide range of applications [Van der Lee, et al 2005; Zhang, L. et al 2004; Bezemer, G. L. et al 2005; Toebes, M. L.M. K. et al 2003]. In this paper, we synthesised Micro Fibre Carbon (MFC) from Tannery Solid Waste using pulse-pyrolysis without converting Cr (III) to Cr (VI) and utilization of MFC for Making Pavement Materials.

Experimental

2.1 Collection and characterization of TSW

TSW used in the study was collected from Blue Diamond leather manufacture industry in Chennai, Tamil Nadu. TSW was characterized for moisture content, ash content, Chromium (III) and chromium (VI) according to the DIN protocol [4]. Thermo-gravimetric analysis (TGA) and Differential scanning calorimetry (DSC) were carried under nitrogen atmosphere using Q50 TA and **Q200** instruments respectively. Elemental analysis (CHNS) studies were carried out, using vario micro CHNSO15091002 analyzers.

2.2 Preparation of Micro Fibrous Carbon (MFC)

The pyrolysis of a TBD in the O_2 atmosphere has been carried out in a stainless steel (316 grades) vertical retort of weight 13 kg, which was placed in an electrical furnace. Flash pyrolysis was carried upto 550°C and slow pyrolysis up to 800 °C with application of O_2 at the rate of 1LPM was carried out. The applied O_2 supply was only for 10 minutes upto 500°C and another 10 minutes in the temperature of 600-700 °C. Results indicate that, in the range of low temperatures, the product distribution is slightly dependent on temperature. The main aim of the present investigation is to prevent the oxidation of Chromium (III) to chromium (VI) while maintaining the incineration of organic compounds in TBD.

Segment I: $30^oC \rightarrow 500^oC$ (rate of heating at $500^oCh{-}1$)
Segment II: $500^oC \rightarrow 700^oC$ (rate of heating at $100^oCh{-}1$)
Segment III: $700^oC \rightarrow 800^oC$ (rate of heating at $100^oCh{-}1$)

The outer jacket of the lid of the incineration vessel was fitted with pipe, it has 7cm thickness in order to prevent condensation of volatile organic compounds back into incinerator, which increases energy recovery efficiency and prevents the heat dissipation from the reactor. The Condensed organic compound collected in the