Fuel 322 (2022) 124241

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Catalytic pyrolysis of chicken manure over various catalysts

Jae-Wang Shim [a], Sumin Pyo [a], Su Shiung Lam [b], Jungho Jae [c], Byong-Hun Jeon [d], Moonis Ali Khan [e], Kun-Yi Andrew Lin [f], Young-Min Kim [g], Sang-Chul Jung [h], Young-Kwon Park [a,*]

[a] School of Environmental Engineering, Universtiy of Seoul, Seoul 02504, Republic of Korea
[b] Higher Institution Centre of Excellence (HICoE), Institute of Tropical Aquaculture and Fisheries (AKUATROP), Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia
[c] School of Chemical Engineering, Pusan National University, Busan 46241, Republic of Korea
[d] Department of Earth Resources and Environmental Engineering, Hanyang University, Seoul 04763, Republic of Korea
[e] Chemistry Department, College of Science, King Saud University, Riyadh 11451, Saudi Arabia
[f] Department of Environmental Engineering, National Chung Hsing University, 250 Kuo-Kuang Road, Taichung, Taiwan
[g] Department of Environmental Engineering, Daegu University, Gyeongsan 38453, Republic of Korea
[h] Department of Environmental Engineering, Sunchon National University, Jeonnam 57922, Republic of Korea

ARTICLE INFO

Keywords:
Chicken manure
Pyrolysis
Nitriles
Aromatic hydrocarbons

ABSTRACT

In this study, non-catalytic and catalytic pyrolysis of chicken manure (CM) were investigated to understand the pyrolysis kinetics and product distribution of CM by thermogravimetric analysis (TGA) and pyrolyzer-gas chromatography/mass spectrometry (Py-GC/MS). TGA and the apparent activation energy changes, calculated using the Ozawa method, indicated that the decomposition of CM was comprised of four reaction stages. The 1st decomposition of CM was likely the decomposition of carbohydrates and lipids, followed by the 2nd decomposition of lignin at high temperatures. The 3rd decomposition was likely involving the decomposition of proteins. At the final stage, metal carbonates in the ash of CM were likely decomposed. Py-GC/MS analysis indicated a decrease in oxygenates, such as furfural, phenol, and fatty acid, after applying acid catalysts. Among the various acid catalysts, HZSM-5(Silica/Alumina = 30), having the strongest acid sites, showed the highest efficiency for the production of aromatic hydrocarbons, followed by HBeta(Silica/Alumina = 25), HY(Silica/Alumina = 30), natural zeolite, spent fluid catalytic cracking catalyst (FCC), and bentonite. Although bentonite and spent FCC were ineffective, natural zeolite showed a catalytic effect on converting oxygenates to aromatic hydrocarbons. On the other hand, the content of a high molecular weight nitrile, hexadecanenitrile, was also increased. Commercial zeolites, HY(Silica/Alumina = 30), HBeta(Silica/Alumina = 25), and HZSM-5(Silica/Alumina = 30), led to higher aromatic formation efficiencies with less hexadecanenitrile formation than other catalysts. These efficiencies were increased significantly by varying the catalyst to CM ratio from 1/1 to 5/1, with a noticeable decrease in hexadecanenitrile.

1. Introduction

The amount of animal manure has increased in recent decades due to the increasing consumption of livestock [1]. As the International Convention on the Prevention of Marine Pollution by Waste came into force in 2006, measures for reducing marine excretion of livestock excreta and sewage and the relevant laws were established in many countries and promoted to achieve the goal of prohibiting the ocean discharge of animal manure [2]. Although composting and liquid fertilizer production processes via the aerobic and anaerobic treatment of livestock manure have been applied widely for the treatment of animal manure together with its recycling, the diversification of livestock manure recycling technology is necessary to decrease the gap between the demand and supply of compost and liquid fertilizer in agricultural industry [3,4] and control the environmental pollution, such as water, air, and soil contamination, which can be increased due to the excessive nutrient released to the soil [5]. Therefore, the energy and fuel production from animal manure could be considered a potential application

* Corresponding author.
E-mail address: catalica@uos.ac.kr (Y.-K. Park).

https://doi.org/10.1016/j.fuel.2022.124241
Received 29 January 2022; Received in revised form 28 March 2022; Accepted 11 April 2022
Available online 26 April 2022