



## Valorisation of medical waste through pyrolysis for a cleaner environment: Progress and challenges<sup>☆</sup>

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### ABSTRACT

The COVID-19 pandemic has exerted great shocks and challenges to the environment, society and economy. Simultaneously, an intractable issue appeared: a considerable number of hazardous medical wastes have been generated from the hospitals, clinics, and other health care facilities, constituting a serious threat to public health and environmental sustainability without proper management. Traditional disposal methods like incineration, landfill and autoclaving are unable to reduce environmental burden due to the issues such as toxic gas release, large land occupation, and unsustainability. While the application of clean and safe pyrolysis technology on the medical wastes treatment to produce high-grade bioproducts has the potential to alleviate the situation. Besides, medical wastes are excellent and ideal raw materials, which possess high hydrogen, carbon content and heating value. Consequently, pyrolysis of medical wastes can deal with wastes and generate valuable products like bio-oil and biochar. Consequently, this paper presents a critical and comprehensive review of the pyrolysis of medical wastes. It demonstrates the feasibility of pyrolysis, which mainly includes pyrolysis characteristics, product properties, related problems, the prospects and future challenges of pyrolysis of medical wastes.

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### 1. Introduction

There is no doubt that the whole world has entered a new era since the global outbreak of Coronavirus Disease 2019 (COVID-19), as more than 109.47 million positive cases and over 2.41 million deaths have been confirmed at the moment of writing the paper (Johns Hopkins University (JHU), 2021). These numbers are increasing continuously every day because of the droplet and contact transmissions, which has an extensive impact on human lives (Wang et al., 2020a). This has also resulted in a series of health, socio-economic, and environmental problems (Mofijur et al., 2021). Among them, the disposal of medical wastes is a tremendous challenge for every nation. Before the global outbreak of COVID-19,

it was reported that just hospitals in America produced over 5.9 million tons of medical wastes annually (Kargar et al., 2020b). Meanwhile, the amount of waste continues to rise because of many reasons other than the COVID-19, such as the increase of elderly population, the improvement of health awareness, the rise in medical services expenditure, and the development of medical technology (Patrício Silva et al., 2020; Peng et al., 2020). The global epidemic further exacerbated the situation, especially for the most affected countries like the USA, Brazil, India, the UK, France, Italy, China, and so on (Kumar et al., 2020b). For example, the generation of medical wastes explosively rose from 3.64 to 27.32 kg/day per 1000 persons in Wuhan since the outbreak of COVID-19, and the personal protective equipment like the protective suit, facemasks, nitrile gloves, safety goggles, and testing kits were the primary components of medical wastes (Di Maria et al., 2020; Singh et al., 2020; Yang et al., 2021).

World Health Organization (WHO) defines medical waste as the waste generated in the diagnosis, treatment or immunisation of human beings or animals (Mohee, 2005). They are hazardous and

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