Exergy Analysis of Ultrasonic-Assisted *ex-situ* Biodiesel Production from Spent Coffee Grounds

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Abstract

Waste management has become a global menace due to increasing waste generation caused by high population growth as well as the lack of efficient management technologies. Spent coffee grounds (SCG), which is the waste generated from coffee brewing, are generated globally at a rate of about 6 million tons annually, which pose environmental concerns as they are disposed of in uncontrolled landfills. SCG contains significant amounts of oil (about 10 – 21% by weight) which can be harnessed for biodiesel production. The growing request for clean energy coupled with the urge for sustainable technologies has accelerated extensive research into the transformation of waste into biofuels. One of the efficient and innovative means of converting SCG oil into biodiesel is by ultrasound assistance where acoustic ultrasonic waves are used to enhance the transesterification process at significantly shorter times. Exergy analysis is a sustainable assessment tool which can pinpoint stages within a manufacturing process where the quality portion of energy and materials or resources (available to do work) is destroyed hence helping engineers to make informed decisions on sustainability. However, ultrasonic biodiesel production may be energy intensive which may result in exergy destruction hence lowering the overall exergy efficiency. In this study, exergy analysis of ultrasonic assisted ex-situ (where SCG oil extraction and transesterification are separately) biodiesel production technology (including the ultrasonic SCG oil extraction, ultrasonic transesterification, SCG biodiesel purification steps) is carried out for process improvement and sustainability. Thermodynamic sustainability indicators such as exergy destruction, exergy efficiency and environmental burdens in terms of exergy are examined and energy improvement options are suggested. Compared to the conventional transesterification without ultrasound where the reaction takes place for long, it was found in this study that ex-situ transesterification of SCG oil assisted by ultrasound significantly improved the exergy efficiency due to improved product yield and significant reduction of reaction time. Thus, SCG represents a potential source of biofuel which can be sustainable in the long term when transformed into biodiesel by ultrasonic assisted means.

Keywords

Spent coffee grounds; waste; biodiesel; ex-situ transesterification; exergy analysis.