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c0033 Chapter 33

Solar intervention in bioenergy

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s0010 33.1 Introduction

p0010 Solar energy is proliferating into almost all forms of bioenergy, namely biogas, biochemicals, biodiesel, bioethanol, biohydrogen, and bioelectricity, making bioenergy production energy efficient, environmentally benign, and sustainable. The growing interest in the field of solar–bioenergy is observed. The growth in this research field was particularly remarkable during the past decade (2010–20), directing policymakers to provide research funding to this field of research to reap rewarding results, like clean energy and environment.

s0015 33.2 Solar intervention in biodiesel production

p0015 Schematic diagrams of the various stages involved in the biodiesel production process, namely transesterification of Karanja oil with the biocatalyst (lipase immobilized on graphene oxide), solar-driven distillation for the recovery of alcohol from biodiesel, and membrane-assisted (polyethersulfone) ultrafiltration for glycerol recovery (77%) are shown in Fig. 33.1 (Kumar and Pal, 2021). Solar energy was used for one of the downstream biodiesel (yield, 88%) purification processes, namely distillation. Recovery of bioethanol used for the transesterification of Karanja oil is achieved using the solar energy-driven direct contact membrane distillation process at a relatively lower temperature than the conventional energy-intensive distillation process. As a result of solar-driven distillation, the ethanol recovery (yield) is ~ 41 kg/m^2/24 h through the commercial polytetrafluoroethylene/polyethylene terephthalate (PTFE/PET) hydrophobic membranes.

p0020 An attempt was made to reduce the cost of production of biodiesel from palm oil, rapeseed oil, and *Chlorella vulgaris* by using the heat generated in a hybrid solar collector/desalination/biomass conversion reactor. The transesterification reactor used for biodiesel production and the parabolic trough collectors (PTC) used for harnessing solar energy are shown in Fig. 33.2A and B, respectively (Mirnezami et al., 2020). The heat generated from parabolic trough solar collectors (PTSCs) is used as a source of temperature (60°C) for the transesterification reactor by circulating the working (heating) fluid through the outer wall of the reactor. A resistance sensor (PT100) was used to monitor the reaction temperature. The reflectors of the PTC were two parabolic mirrors with a reflectance coefficient of 0.9. The absorbent tube of the PTCs comprised an inner tube of copper and an outer glass tube of 2 mm thickness. The radiation entering the solar collector is measured using a pyrometer. The inlet and outlet temperatures of the working fluid used in a heat transfer medium are measured by using a thermocouple. The heat transfer fluid is a hybrid of the base heat transfer fluid (shell heat transfer oil of thermia B) mixed with multiwalled carbon nanotubes and MgO nanoparticles (NPs). CNTs are chosen as nanoadditives to the working fluid owing to their high thermal conductivity (~3000 W/m.K). MgO NPs are selected as the additives to the working fluid due to their high specific heat capacity (985 J/kg.K). The working fluid used in the solar collector is one of the most important components that affect the performance and the efficiency of the hybrid power source. The thermal efficiency of the PTSC was 56.59%. A part of the heat generated in the solar collector is also used for water desalination to reduce the overall cost of solar energy harnessing and biodiesel production. The percentage of conversion of palm oil, rapeseed oil, and *C. vulgaris* to biodiesel at 60°C were 76.31, 74.54, and 81.4%, resulting in a biodiesel production cost of $0.73, 0.54, and 1.27/L, respectively.

p0025 An outdoor open pond completely powered by the electricity generated from solar panels, as shown in Fig. 33.3A, is used for the cultivation of *Nannochloropsis oceanica* SCS-1981, a promising feedstock for biodiesel production and

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