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Review

Photocatalytic production of hydrogen from biomass-derived feedstocks

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ABSTRACT

The application of photocatalysis for the utilisation of sunlight energy is intensely investigated in present times, particularly in prospect of generating solar fuels by hydrogen production or CO_2 reduction processes as tools for societies aiming to relief their thirst for fossil resources. From the perspective of sustainability, the rational use of biomass-derived feedstocks for photocatalytic H_2 production is a feasible, proven and highly efficient process. In this review, in addition to delving into physico-chemical fundamentals of photocatalytic processes on semiconductors, the research activity on this topic related to the design of revolutionary semiconductor-based materials, generally including metallic nanoparticles or complexes as hydrogen-evolving co-catalysts, is outlined and critically evaluated. Moreover, the use of sunlight and renewable feedstocks for the generation of hydrogen, as a compelling opportunity for the energy sector, is emphasised. Special focus is also set on the valorisation of biorefinery products, agricultural residues and industrial or municipal waste.

1. Introduction

The success of future energy schemes is expected to heavily depend on the rational transition from the exploitation of fossil fuels to the efficient use of renewable energies. The judicious transformation of biomass resources into fuels appears as a convenient strategy in these terms, given the rich chemistry developed in recent years and the suitability of the thereby generated biofuels to fit current power and transportation infrastructures [1]. Moreover, sunlight is regarded as the ultimate source of energy for any long-term sustainable future [2]. Its storage in the form of solar fuels is one of the most desirable options [3]. Among such strategies, solar production of hydrogen as a clean energy carrier is particularly compelling [2b,c,4]. The design of photocatalytic or photoelectrocatalytic systems has enabled the realisation of overall water splitting in one step, yet at low efficiencies under visible light—hardly surpassing 5% for the best performers [5]. Discouraging as they may appear, these are excellent values since they pave the way to a direct solar-to-fuel scenario whereby sunlight energy is stored in the form of chemical energy. The intensive