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Production of Black Phosphorus Doped Metal Chalcogen Hybrid Materials and Their Use in Photocatalytic Hydrogen Production

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I. Introduction

Today's problems such as energy crisis and explosions have accelerated research on the spread of party and environmentally friendly energy (Wang et al., 2009). Photocatalytic energy production has significant potential as a clean and sustainable energy source. These structural, next-generation hybrid materials such as metal chalcogen and black phosphorus have great potential for the availability of photocatalytic growth (Deng et al., 2016). This ability is the production of metal chalcogens by producing tubes and the ability to use the storage capacity by the photocatalytic (PCHER) method.

II. Experimental Studies

The photocatalytic Proton Coupled Electron Transfer (PCHER) method is a mechanism that enables the photochemical breakdown of water under the influence of sunlight (Wilson, 2020). In this method, the material used as a photocatalyst absorbs sunlight and catalyzes the separation of water molecules into oxygen and hydrogen gases. Metal chalcogen and black phosphorus hybrid materials provide high efficiency hydrogen production via the photocatalytic PCHER method.

Metal chalcogens are synthesized by chemical vapor deposition in a tube furnace at 800°C for 3 hours in Argon atmosphere. This method allows the creation of the crystal structure of the material at high temperatures and under controlled atmospheres. In this study, $MoWS_2$, MoW_2S_2, Mo_2WS_2 structures were synthesized by mixing the metal chalcogens MoS_2 and WS_2 in different ratios (1:1; 1:2; 1:3). Photocatalytic hydrogen production was examined by adding the black phosphorus we produced to these structures.

Black phosphorus is synthesized by hydrothermal method in an autoclave at 200°C for 7 hours.

The photocatalytic hydrogen performances of MoS_2, WS_2, $MoWS_2$, MoW_2S_2, Mo_2WS_2 structures produced in the photocatalytic reactor system shown in Figure 1. were tested.

All tests were carried out for two hours. After two hours of tests, the system was mixed and precipitated again and measurements were taken again.

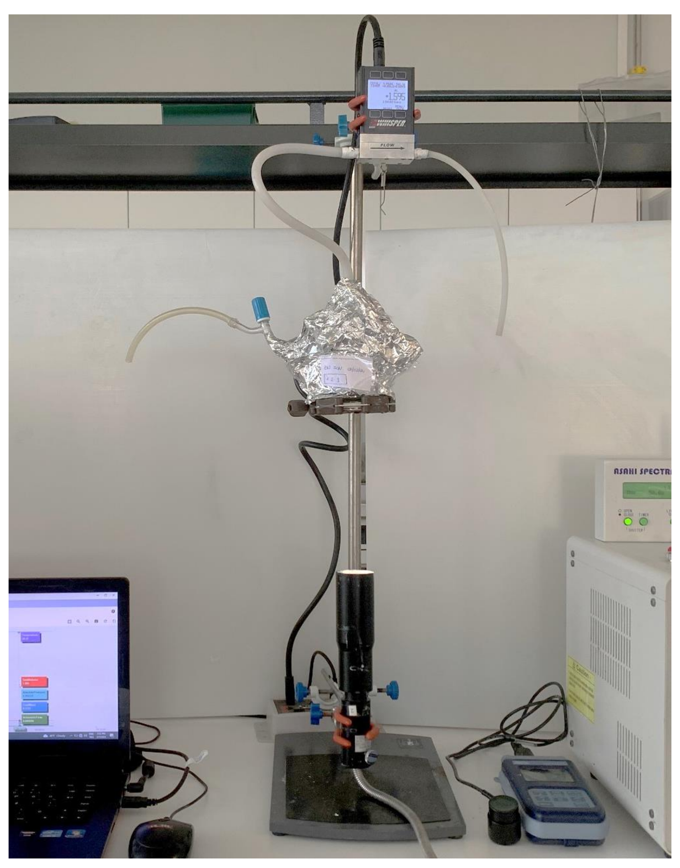
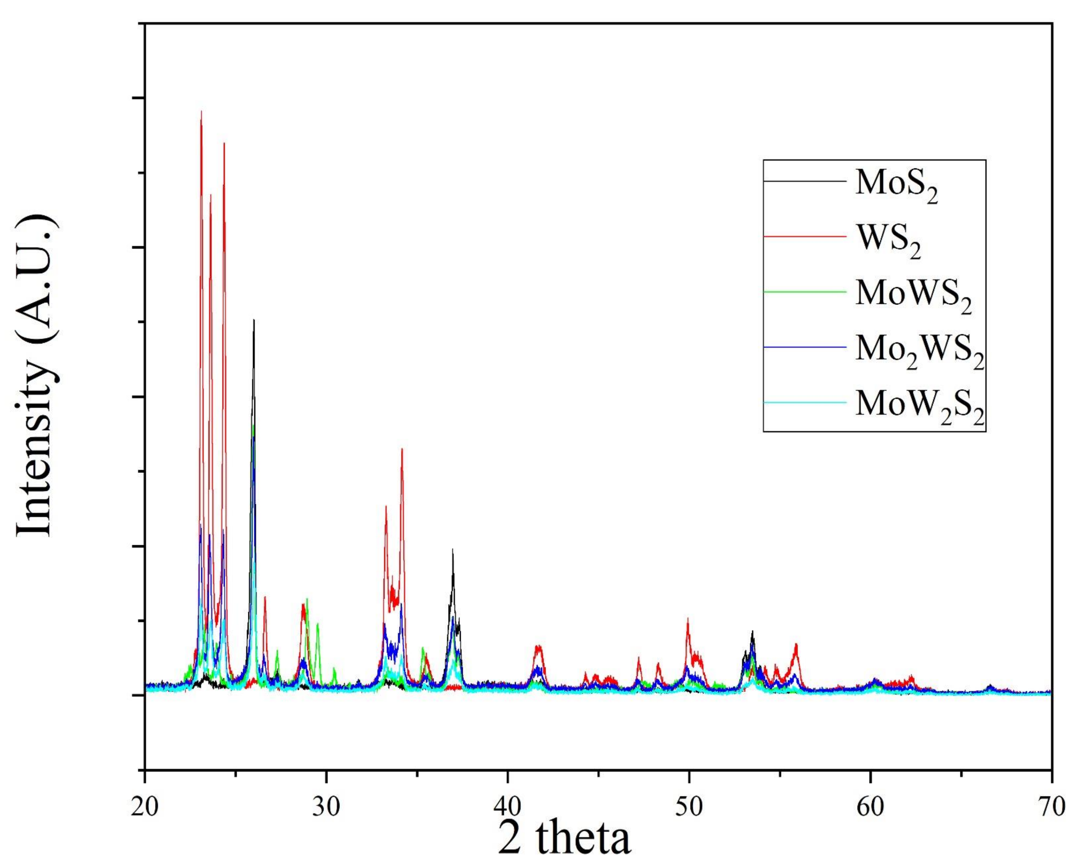
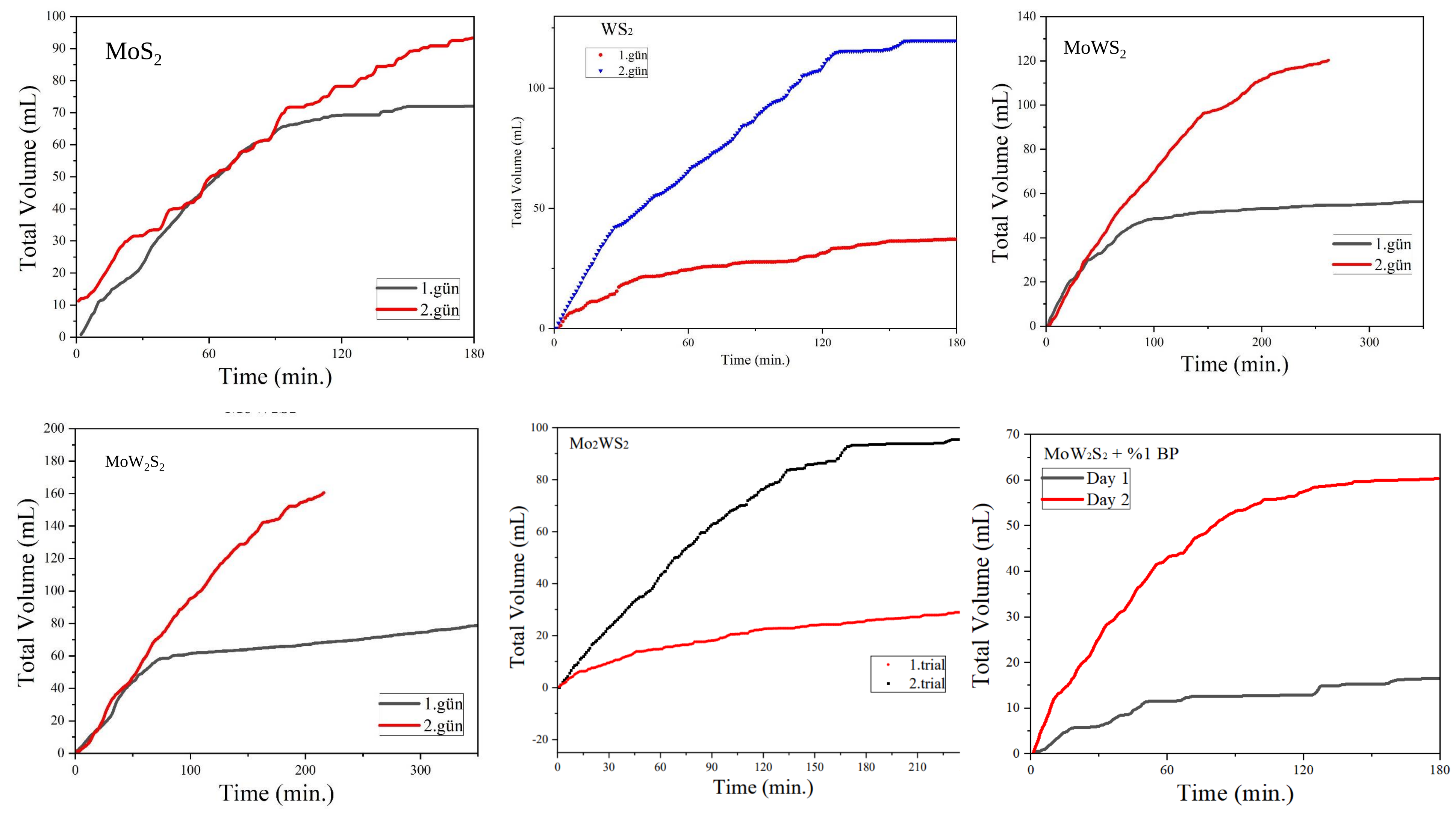


Figure 1. Photocatalytic Reactor System



Graphic 2. XRD analysis results of MoS_2, WS_2, $MoWS_2$, MoW_2S_2, Mo_2WS_2

III. Analyses



Graphics 2-7. Change of hydrogen production over time in PCHER performed under 1 sun light in the sacrificial electrolyte of 0.350 M Na_2S and 0.250 M Na_2SO_3 aqueous solution of MoS_2, WS_2, $MoWS_2$, MoW_2S_2, Mo_2WS_2, MoW_2S_2%1BP photocatalysts.

Graphics 1-6 show the hydrogen production rates of PCHER analyzes performed with MoS_2, WS_2, $MoWS_2$, MoW_2S_2, Mo_2WS_2 structures. When these analyzes were compared, the highest hydrogen production rate was achieved with the WS_2 structure. The maximum hydrogen production amount of the WS_2 structure was measured as 95.49 $mLh^{-1}g^{-1}$.

	TOTAL H2 VOLUME ($mL\ h^{-1}g^{-1}$)	
PHOTOCATALIZER	1 HOUR	2 HOUR
MoS_2	49.54	78.22
WS_2	95.49	168.24
$MoWS_2$	46.85	82.08
MoW_2S_2	43.17	76.29
Mo_2WS_2	58.37	110.85
MoW_2S_2 %1 BP	42.97	57.56

Table 1. PCHER hydrogen production time variation in photocatalyst electrolytes of 1 sun, 0.350 M Na_2S and 0.250 M Na_2SO_3 aqueous solutions

Results and Evaluation

The photocatalytic hydrogen production performance of the obtained metal chalcogen and black phosphorus hybrid materials was examined under various conditions and catalysts. Various experiments were carried out to determine the optimum conditions and increase the efficiency of the catalysts and the results were evaluated. The findings show that metal chalcogen and black phosphorus hybrid materials have high photocatalytic activity and have a significant potential in hydrogen production by effectively using sunlight.

Acknowledgement

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