GREEN HYDROGEN ENERGY USING PBBR2 UNDER ELECTROCHEMICAL WATER SPLITTING

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ABSTRACT

Green route hydrogen extracted from renewable energy sources through the splitting of water is an emerging and promising energy carrier for the upcoming years, and industries like steel production and chemical manufacturing, like ammonia, are exploring green hydrogen. Lead Bromide perovskites are known for high absorption coefficients, excellent charge transport, optical application, etc, and doped lead bromide perovskites are efficient to use as catalysts for the production of green hydrogen. The electrodes doped with-$PbBr_2$/NF reinforced the conductivity, and their nanosheet structure, which offers a large surface area for catalytic activity, are the most promising electrocatalysts for HER compared to pure $PbBr_2$/NF, especially in an alkaline medium, because of its outstanding catalytic activity, excellent stability, and simple production method. The parameter, low onset potential and low overpotential, makes the electrodes efficient electro-catalysts for HER.

Keywords: Water Splitting, Electrochemical Analysis, Hydrogen Evolution Reaction, Lead Bromide Nanocomposites

1. INTRODUCTION

The interest in hydrogen has risen to a peak level as it can be used as both an energy carrier and a primary energy source, if extracted from the ground as naturally occurring hydrogen. As an energy carrier, it stores and transports energy, produced from various resources like fossil fuels, solar, water, and biomass. It can be created directly from biomass or fossil fuels, recovered from geologic reservoirs, or by generating electricity through water, which splits water into its component elements of oxygen and hydrogen without producing any byproducts [1,2]. The planet imagines a future "hydrogen economy," in which hydrogen is generated from a variety of renewable energy sources, stored for later use, piped to the desired location, and cleanly transformed into electricity and heat. Hydrogen is utilized as a rocket fuel, in industrial processes, and in fuel cells that generate electricity and power automobiles. Hydrogen is being investigated by operators of a number of natural gas-fired power stations as a natural gas substitute or supplement. Indirect energy storage for the production of electricity is a possibility with hydrogen [3].

Water steam is the only output from a hydrogen-powered fuel cell vehicle. Therefore, hydrogen is a clean fuel for automobiles since it doesn't release any toxins or greenhouse gases that cause climate change. Because of its high energy content per unit of weight, hydrogen is a tremendous source of energy and is utilized as rocket fuel. Green hydrogen capability is being built by nations all over the world because it can help reduce carbon emissions and guarantee energy security. With the world experiencing its worst energy crisis ever and the fear of climate change becoming a reality, green hydrogen has become a global catchphrase.

An electrolyser that separates hydrogen from water molecules is powered by electricity to create green hydrogen. Pure hydrogen is produced by this technique; no hazardous byproducts are produced [6]. Another advantage of this technology is that, because it uses electricity, it has the potential to use any excess electricity, such as surplus wind power, for electrolysis, which produces hydrogen gas, which can be stored for multipurpose use in the future. White hydrogen is pure hydrogen that occurs naturally underground and is created by geological events. It appears when water deep within the Earth's crust reacts with minerals. Additionally, pressurized stationary or portable tanks and specialized hydrogen gas pipeline infrastructure can store gaseous hydrogen in comparatively smaller volumes. The most popular and likely way to increase hydrogen storage for the majority of hydrogen uses as an energy source is through gaseous storage [7].

For the time being, most hydrogen is produced traditionally by burning fossil fuels, which releases a large amount of CO2. Thus, the largest challenge is to produce hydrogen using sustainable energy sources like solar panels and wind turbines. This is the most important action that needs to be taken in order to move toward green hydrogen. Hydrogen produced from renewable energy sources is substantially more expensive and less efficient than hydrogen produced from natural gas. Furthermore, thanks to large investments in lithium-ion battery technology, the price of this class of electric vehicles is rapidly decreasing [8].

Types	**Source**
Green Hydrogen	Green Hydrogen is produced by splitting the water by a process called electrolysis with no CO_2 emission during the production process.
Blue Hydrogen	Blue Hydrogen is produced by splitting the natural gas into Hydrogen and CO_2 which is released into atmosphere.
Grey Hydrogen	Grey Hydrogen is produced by splitting the natural gas into Hydrogen and CO_2 which is released into atmosphere.
Black/Brown Hydrogen	Brown and Black Hydrogen are produced from coal via gasification and CO_2 and CO are produced as by-products.
Turquoise Hydrogen	Turquoise Hydrogen is produced by thermal splitting of Methane via Methane Pyrolysis, causes the carbon as by-product in a solid form.
Purple Hydrogen	Purple Hydrogen is produced by using nuclear power and heat through the chemo- thermal electrolysis splitting of water.
Pink Hydrogen	Pink Hydrogen is produced from the electrolysis of water by using electricity from a nuclear power plant.
Red Hydrogen	Red Hydrogen is produced by using nuclear power thermal energy through the high-temperature catalytic splitting of water.
White hydrogen	White Hydrogen is the naturally occurring hydrogen which is found in the earth crust, extracted by fracking.

Fig.1: Classification of Hydrogen[5]

2. EXPERIMENTAL SECTION

Preparation of PbBr2 nanoparticles: Synthesis of nanoparticles was done using the chemicals $(CH_3COO)_2$ Pb * $3H_2O$, KBr, ammonia, NaOH, Oxalic acid and the experiments were performed without any further purification. Initially, 50 ml of distilled water was added to a beaker and stirred for 10 min. $(CH_3COO)\ _2Pb$ * $3H_2O$ weighing 2.945g was added. 8.1 g of KBr were added to the solution after 10 min, at which point the colour changed to yellow. The solution's pH has been measured a few times at intervals of five minutes. The pH of the suspension was adjusted to 11 by fusing 10 milliliter of ammonia. After that, the solution was moved to a Teflon-lined autoclave reactor and kept there for eighteen hours at 150 degrees Celsius. After centrifuging the resultant powder, the finished product was dried for four hours at 80ºC. We have extracted the PbBr2: Oxalate concentration from 0.5 g of the whole yield. A concentration of 85:15 was applied to the beaker for ultrasonication. After that, the solution was switched to a Teflon-coated autoclave reactor and kept there for eight hours at 120°C. After being cleaned and collected in a centrifuge, the resulting powder of Oxalate doped PbBr2 was dried at 80 degrees for two hours. Similar steps are followed for the synthesis of Fe and Co-doped PbBr2.

Fabrication of Working Electrodes: Working electrode fabrication involved sonicating 0.1 g of synthesized materials for 30 minutes after dispersing them in 10 ml of isopropyl alcohol. In the meantime, Ni foam was cut into 2×2 cm2 pieces as purchased, sonicated for 5 minutes in 2.5 M HCl, and then washed with distilled water and acetone. Following that, a separate drop-cast of the prepared material suspension with an active area of 4 cm2 was made on the Ni foam. Nickel foams that had been drop-cast were dried at 60°C for 30 minutes. The hydrogen evolution reaction in the 1 M KOH electrolyte was next investigated using the produced working electrodes.

3. RESULT AND DISCUSSION

The XRD pattern of PbBr2 sample was recorded at room temperature at the range of 20 º to 80 º is shown in Fig. 2a which indicates that all the reflection peaks in the XRD pattern shown crystalline nature. The presence of planes (002), (020), (011), (111), (220), (031), (040), and (232) in the XRD pattern reveals the orthorhombic phase structure of the samples. The average crystalline size of the nano sample is calculated as 12.25nm by using the Scherrer's formula. In Fig. 2b, PbBr2 nanoparticles spectrum is observed and characteristic absorption peak of the sample is noted that at 210nm and 265nm with band gap of 5.9eV and 4.67eV respectively.

Fig. 2d illustrated the linear sweep voltammetry curves (LSV) of the PbBr2 and doped PbBr2 for the HER. As expected, Fe and Co doped PbBr2/NF exhibited efficient HER activity with much lower onset potential and greater current density than Oxalate doped PbBr2 /NF and pure PbBr2.

The electrochemical interface and effective charge transfer between the electrodes and the electrolyte are indicated by the semicircles in the EIS spectra. At high frequencies, the charge transfer resistance and impedance equal the solution resistance, as shown by the semicircle drawn by the Nyquist plot Fig.2c. The distance between the origin and the high frequency data points represents the solution resistance, whereas the high frequency impedance is displayed on the left side of the Nyquist plot. The low-frequency impedance data, however, is situated on the other side of the semicircle. When the frequency is very low or close to zero, the impedance is equal to the sum of the charge transfer resistance and solution resistance [10].

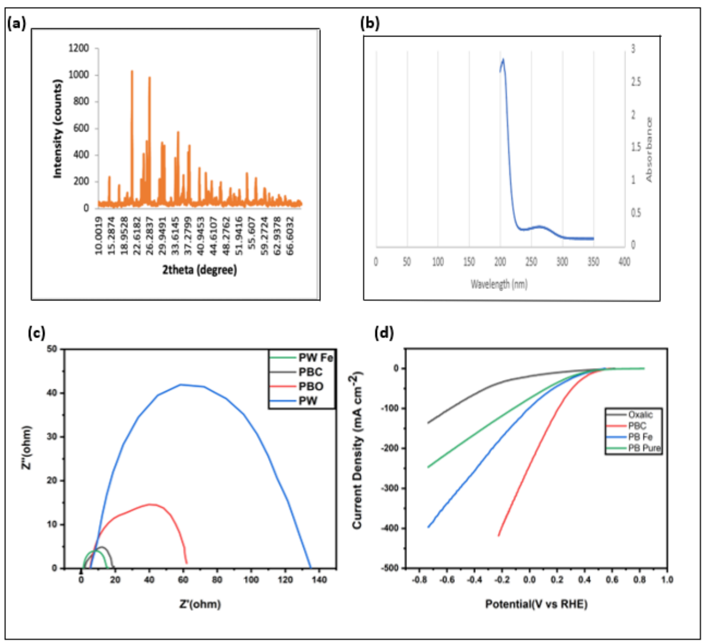

Figure 2 (a) XRD pattern, (b) UV spectra of PbBr2, (c) linear sweep voltammetry curves, (d) electrochemical impedance spectroscopy curves

4. CONCLUSION

When the quantity of renewable energy is high, hydrogen could be created using renewable resources; when the electricity demand is high and renewable resources are scarce, hydrogen might be stored to provide electricity. Green route hydrogen energy may be delivered or stored, which acts as an energy carrier rather than hydrogen energy as an energy source. Fuel cells may use hydrogen to produce power and heat, or electricity. The most popular uses of hydrogen nowadays are in fertilizer manufacturing and petroleum refining, with utilities and transportation being newer sectors. In various applications, hydrogen and fuel cells have the potential to lower greenhouse gas emissions because of their high efficiency and production of clean energy. The biggest obstacle to producing green hydrogen, especially from renewable resources, is the cost and efficiency. In the current work, the Doped PbBr2 electrode behaves as a good catalyst with a low onset potential and overpotential.

CONFLICT OF INTERESTS

None.

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