

Preparation of Sodium Hydroxide By Utilization Of Biodegradable Waste-Derived Sensitizers Using Solar Energy

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Abstract

Now a days natural dyes have emerged as a sustainable, environment friendly, economically viable alternative to synthetic dyes [1]. This article focused on utilization of extracted natural dyes i.e. Yellow Marigold Flower Dye and Dried Walnut Shells Dye from biodegradable waste [which are ; Yellow Marigold Flower (*Tagetes erecta*) waste and Dried Walnut Shells waste] as a sensitizers in closed four sided 'Cuboidal-Dye Sensitized Solar Cell' (Cuboidal-DSSC) for sodium hydroxide production. The aim was to use of a sustainable energy i.e. Solar Energy as energy source rather than using Electricity which is used as a energy source in conventional methods for sodium hydroxide production, but along with this the another advantage is along with sodium hydroxide production Electricity is being produced from our fabricated closed four sided 'Cuboidal-Dye Sensitized Solar Cell'. And we will use this prepared sodium hydroxide (in our 'Cuboidal-Dye Sensitized Solar Cell') in our further research for Biofuel production.

Introduction

The photovoltaic Solar cell is an another source of energy, which generates energy in the form of electricity. The dye – sensitized solar cells (DSSCs) represent a substitute for silicon based solar cells that are interesting owing to their low-cost manufacturing, non-toxicity with good recovery efficiency [6]. Herein we manufactured a closed four sided 'Cuboidal-Dye Sensitized Solar Cell' using 5 conductive glass plates (this Cuboidal shaped were prepared to collect the formed sodium hydroxide in it) containing an mixture of 'NaCl + Distilled water + Ethanol' as electrolyte. Our used electrolyte is green in nature, environment friendly, and non-toxic in comparison with conventional electrolyte i.e. Iodide/Triiodide redox couple used in conventional DSSCs.

This paper discusses the simple extraction techniques without any further purification of natural dyes. For this we took Dried Walnut Shells waste, then we collected the flower waste generated from Temples then we segregated Yellow Marigold Flower from it. We also measured open-circuit voltage $[V(oc)]$ of each extracted dye separately one by one and then measured open-circuit voltage $[V(oc)]$ of both the dyes in the form of their Cocktail by using multimeter in our closed four sided 'Cuboidal-Dye Sensitized Solar Cell'.

Sodium Hydroxide is one of the most versatile and vital industrial chemicals. Sodium Hydroxide is primarily made through the Chlor-alkali process, which involves electrolysis of a brine (salt water) solution producing Sodium hydroxide, Chlorine gas, Hydrogen gas. But main disadvantages of Chlor-alkali process is that, it generally involves environmental hazards. The electrolysis stage as it is non-spontaneous requires electricity. Electricity is the primary driver of the carbon footprint, especially if it is relying on fossil fuels. Our aim was to prepare sodium hydroxide in more Greener way using solar energy (sunlight) as energy source in 'Cuboidal-Dye Sensitized Solar Cell' rather than using Electricity which is used as energy source in conventional processes such as Chlor-alkali process.

Experimental Work

Collection of Biodegradable Wastes :-

In our research for extraction of Yellow Marigold Flower Dye and Dried Walnut Shells Dye, we have used biodegradable wastes i.e. Yellow Marigold Flowers (*Tagetes erecta*) waste and Dried Walnut Shells (*Juglans regia*) waste.

Biodegradable wastes used in this research were sourced from local waste streams.

Yellow Marigold Flowers (*Tagetes erecta*) were collected as post-ritual floral waste from a local temple in [City : Amalner, Dist : Jalgaon, State : Maharashtra, Country : India]. The flowers were sorted to remove non-botanical debris, washed with distilled water and sun-dried for 2 to 3 days.

Dried Walnut Shells (*Juglans regia*) were obtained from domestic kitchen waste streams in [City : Amalner, Dist : Jalgaon, State : Maharashtra, Country : India]. We took this obtained Dried Walnut Shells waste and cleaned it , and mechanical grinded it with the help of mortar and pestle.

1. Extraction Of Dyes : For this we have used 90% Ethanol as a solvent for extraction ;

A] Extraction Of Yellow Marigold Flower Dye : For this we took dried petals of Yellow Marigold Flower and then powdered it. Then we took 6 gm of this powder and add into 70 ml of 90% ethanol. Then we heat this mixture in water bath for 90 minutes between the temperature of 40°C – 70°C on hot plate magnetic stirrer with continuous stirring. After cooling and filtered this mixture we got our dye.

B] Extraction Of Dried Walnut Shells Dye : We took 30 gm of grinded Dried Walnut Shells then add this into 210 ml of 90% ethanol and then soaked this mixture for 48 hours at room temperature. Then we heat this mixture in water bath for 180 minutes between the temperature of 40°C – 70°C with occasional stirring, then we let that mixture at rest as it is for next 24 hours at room temperature, on next day we took that same mixture and heat it in water bath for 60 minutes between the temperature of 40°C – 70°C with occasional stirring. After cooling and filtered this mixture we got our dye.

2. Preparation Of Electrolyte Solution : To prepare electrolyte solution; dissolved 0.8 gm of sodium chloride (solid) in 10 ml of distilled water then filtered it, after that addition of 3 ml of 90% ethanol to resulting filtrate. The resulting solution is the electrolyte solution.

Then addition of 2 to 3 drops of phenolphthalein indicator (to check the formation of sodium hydroxide during the course of operation in Cuboidal-DSSC) into the prepared electrolyte solution.

3. Manufacturing And Fabrication Of 'Cuboidal – Dye Sensitized Solar Cell' : We took 5 transparent conductive glass plates and made closed four sided 'Cuboidal – Dye Sensitized Solar Cell' structure having conductive sides facing inward so that the resulting cathode and anode fabricated on glass plates would be in contact with electrolyte solution. We used conductive glass plates having dimension of L = 25 mm and W = 25 mm. And we used Silicone waterproof sealant and adhesive for making this Cuboidal shape. Then we fabricated our prepared Cuboidal-DSSC by coating one inward transparent

conductive glass plate with carbon which would act as cathode and another inward transparent conductive glass plate facing opposite to cathode with Titanium dioxide paste (and sintered it at 80°C for first 15 minutes and then at 120°C for next 2 hours in Hot Air Oven) this would act as anode. We will sensitize this anode by our dyes.

Result and Discussion

We used multimeter to measure open-circuit voltage. We measured open-circuit voltage of our fabricated 'Cuboidal – Dye Sensitized Solar Cell' contained our prepared electrolyte (mentioned above) sensitized with our dyes one by one separately and then measured open-circuit voltage for their Cocktail dye in sunlight;

- a. Open-circuit voltage $[V(oc)]$ for Yellow Marigold Flower Dye = 0.53 V
- b. Open-circuit voltage $[V(oc)]$ for Dried Walnut Shell Dye = 0.53 V
- c. Ope
- d. n-circuit voltage $[V(oc)]$ for Cocktail Dye (of Yellow Marigold

Flower Dye and Dried Walnut Shell Dye in 1:1 ratio) = 0.62 V

The generated open-circuit voltage $[V(oc)]$ indicates the production of Electricity in all above three setups.

Then we took two fabricated Cuboidal-DSSC's each containing the above prepared electrolyte solution + 2 to 3 drops of phenolphthalein indicator and both are sensitized with the cocktail dye (of yellow marigold flower dye and dried walnut shells dye in 1:1 ratio) and then connected them in series and put them in Sunlight. In sunlight, Sodium Hydroxide produced (which were confirmed by added phenolphthalein indicator which changed from colorless to faint pink during the course of operation) within first 60 minutes at the edges of the both the Cuboidal-DSSC's [Fig.1] and after 12 hours of sunlight exposure pink color appeared at the cathode (which confirms the production of sodium hydroxide at cathode) in both the Cuboidal-DSSC's [Fig.2]. This confirms the production of Sodium Hydroxide (which were confirmed by added phenolphthalein indicator which changed from colorless to faint pink during the course of operation) in both the Cuboidal-DSSC's in presence of sunlight. And these two Cuboidal-DSSC's connected in series produced open-circuit voltage $[V(oc)]$ of 1.24 V in Sunlight. The generated open-circuit voltage $[V(oc)]$ indicates the production of Electricity along with the production of Sodium Hydroxide in presence of sunlight.

And then collected the produced Sodium Hydroxide [Fig.3].

Declarations

Funding Declarations : The Authors [D. J. Kashyap and A. P. Manake] received no financial support for the research, authorship and/or publication of this article.

Clinical Trial Registration : Not applicable.

Consent To Publish : Not applicable.

Consent To Participate : Not applicable.

Ethics Declaration : The plant materials, including Yellow Marigold Flowers (*Tagetes erecta*) used in this research were collected as floral waste from local temple waste streams and Dried Walnut Shells (*Juglans regia*) used in this research were collected from domestic kitchen waste. As these materials were discarded waste products and not harvested from the wild, no specific collection permissions or ethical licences were required under local or national guidelines. No human participants or animal subjects were involved in this research; therefore, formal ethical approval was not required.

Data Availability Statement

The data supporting this article are included within the article and its supplementary information.

Author Contribution

The Authors [D. J. Kashyap and A. P. Manake] wrote the main manuscript text and figures. Both the authors i.e. D. J. Kashyap and A.P. Manake made substantial technical contributions to the conception and development of the conducted research. Both the authors i.e. D. J. Kashyap and A. P. Manake reviewed the manuscript.

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Figures

Fig. 1 :



Figure 1

(Sodium Hydroxide formation at the edges of the Cuboidal-DSSC's after 60 minutes in Sunlight)

Fig. 2 :



Figure 2

(Sodium Hydroxide production at cathode after 12 hours in both the Cuboidal-DSSC's in Sunlight)

Fig. 3 :

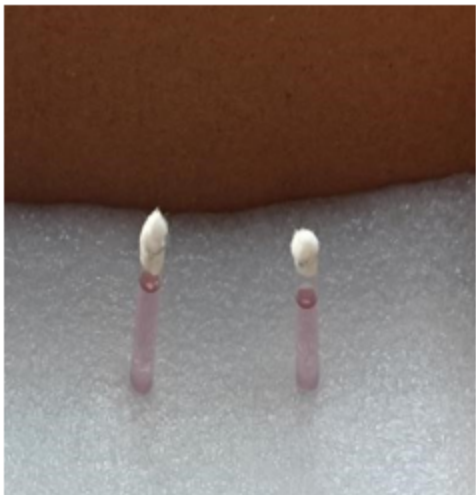


Figure 3

(Collected produced Sodium Hydroxide)

A] Fabricated closed 4 sided 'Cuboidal – DSSC' :



B] NaOH formation is confirmed as phenolphthalein indicator changed from colourless to faint pink at Cathode. :



Figure 4

See image above for figure legend

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