Recycling waste plastics into clean hydrogen gas and nanomaterials for application in supercapacitors

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Summary

The energy crisis and environmental degradation are the major problems facing humanity today. This is due to the growing population, the rapid growth of industry, and the disposal of various solid wastes, which are regularly produced. To solve these problems, scientists are making great efforts to explore the possibility of using appropriate technologies for energy recovery and storage using cheap and abundant carbon sources such as plastic waste. Transforming waste into energy is not just a way to get rid of garbage. It is a way to restore valuable resources. Waste-to-energy is a vital part of a sustainable waste management chain and is fully complementary to recycling. Moreover, the continuous reduction of fossil fuels has led to great efforts in developing high-performance electrochemical energy storage sources such as supercapacitors. The performance of energy storage devices critically depends on the material properties of their components. Supercapacitor technology can benefit significantly by moving from conventional to nanostructured electrodes, because of the superior and unique characteristics of carbon nanomaterials. In this sense, carbon nanomaterials are the most promising electrode materials for supercapacitors. On the other hand, plastic is the most widely used industrial material in our daily life. The high rate of plastic consumption has led to an increase in the amount of waste generated from it, which causes greater problems for its disposal. Since plastic waste resists natural decomposition, getting rid of accumulated plastic waste is a major challenge for the environment. The disposal of plastic waste by incineration in the air or burial in the soil causes severe damage to humans and the environment, as well as loss of natural resources. The world is now moving towards zero-waste technology according to the green and safe environment.

Due to the energy crisis, it is time to move forward to the conversion of waste into clean energy. Moreover, the use of carbon nanomaterials (CNMs) derived from waste plastics for the application of supercapacitors has received great attention.

As shown in Fig. 1, **the main target of this project** is to convert plastic waste into H_2 gas, as a clean fuel, and CNMs for application in supercapacitors. Herein, the recycling of cheap and abundant plastic waste for the sustainable production of clean H_2 gas can make the economic return of the process more significant. Moreover, the byproduct of the recycling process is valuable carbon nanomaterials (carbon nanotubes, graphene nanosheets, carbon nanofiber, and carbon nano-onions). The most important feature of this project is the possibility of its actual application on a semi-industrial scale.

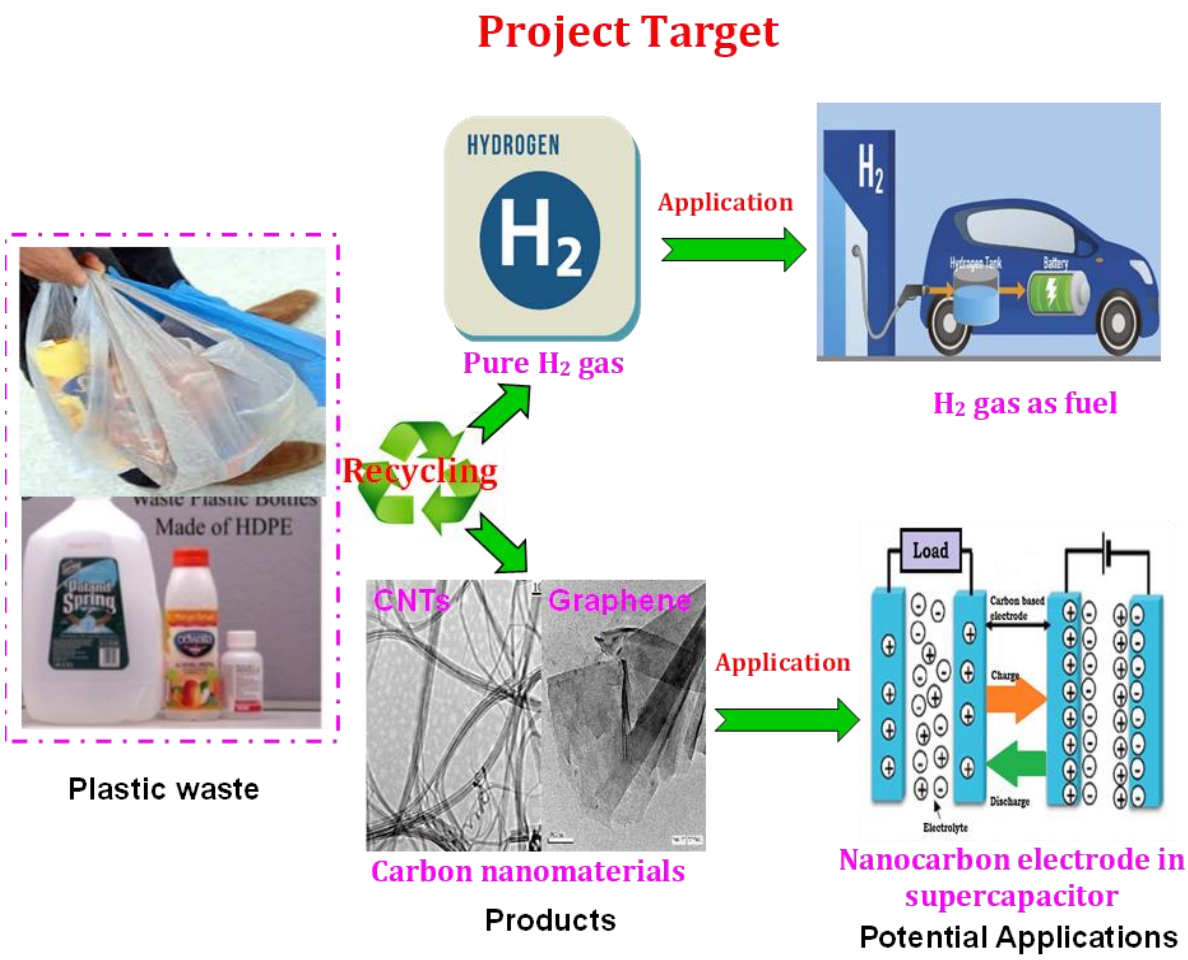

Fig. 1. The main objectives and of the present project

The objectives and impacts of the present project can be summarized as follows: -

1. High yield production of hydrogen gas as a clean fuel by using waste plastics as Feedstock materials.
2. Develop cost-effective processes for producing carbon nanomaterials (CNMs) from different plastic wastes.
3. Investigate the electrochemical efficiency of the prepared CNMs as electrode in supercapacitor.
4. Preserving natural resources by converting waste plastics, which originate from petroleum oil, into clean H_2 gas and CNMs.
5. Reduce the carbon dioxide that can be emitted from the uncontrolled incineration of plastic waste.

In this experimental work of the project, a two-stage method can be utilized for the production of CO_x-free H_2 gas via pyrolysis-catalysis of plastic waste. Different types of waste plastics such as high-density polyethylene (HDPE), low-density polyethylene (LDPE), polystyrene (PS), polyethylene terephthalate (PET), and polypropylene (PP) could be used as feedstock materials. These polymers are the most common in household wastes and account for more than two-thirds of the total polymer consumption in Egypt.