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Review Article

An overview on the use of nanotechnology in the renewable energy field

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ABSTRACT

Nanotechnology is extremely important for efficient use, storage and production of energy. In this context, it is one of the main objectives to contribute to cleaner, sustainable, production by reducing energy use with raw materials. Thus, it is ensured to prevent waste from various sources and to develop environmentally friendly production systems that produce less waste. Nanotechnology in the field of renewable energy sources, which is thought to be a solution to global warming that disrupts the natural balance, is one of the popular topics of today's technology. In this study, information is given about the usage areas of nanotechnology and its applications in the field of energy.

Keywords: Energy; Nanotechnology; Renewable Energy

1. Introduction

Reasons such as rapidly increasing world population, gaining new dimensions of industrialization and increasing the standard of living increase the need of people for energy. This situation pushes developed and developing countries to new searches in terms of energy policies. Energy production from fossil fuels is one of the most important causes of environmental pollution. It is thought that fossil fuel reserves will decrease by 2050, and the global energy need in 2050 and 2100 is estimated to be 30 and 46 TW, respectively. The carbon dioxide and methane gases produced by the commonly used fossil fuels harm human and environment. Global consumption of fossil fuels, greenhouse gases and emissions of other toxic pollutants reach alarming and environmentally unacceptable levels [1,2].

Among the topics considered as the most important problem today is the development of renewable energy technologies for energy production - use.

The future sustainable development of society is based on renewable and environmentally friendly alternative energy sources. These energy sources can be listed as solar, wind, biomass, hydrogen and geothermal energy. These clean sources can be used alternatively to traditional energy sources. These sources are expected to provide 50% of the world's primary energy by 2040 [3].

Nanotechnology has gained attention in recent years with its use in science and engineering and technological fields. As in many fields, nanotechnology has provided new possibilities to solve problems that need to be overcome. Global energy consumption, which is one of the important problems of our age, is expected to decrease significantly thanks to nanotechnology. While countries are working on preventing the consumption of natural resources, researches are conducted on finding and making new energy resources available [4]. Nanotechnology has applications in the efficient use, storage and production of energy, as well as in

the detection and cleaning of environmental pollutants. It is known that nanotechnology, which provides applications such as providing clean drinking water, improving the quality of the air, developing new energy sources and also removing dangerous and toxic substances from the environment we live in, is effective in creating a sustainable environment [5]. In wind energy, productivity feasible is increased by using light and more resistant nano-products in rotor part. In biomass, nanomaterials precision agriculture can be used to increase the productivity of the crop used in biofuel production. In tidal powered vehicles, nano-coated materials can be used to limit the corrosion. In addition, some composites have been used to produce drilling machines resistant to fatigue in geothermal energy. Nanoscale coatings are used in films that convert solar energy into electricity and collector systems that transform solar energy into heat energy [3].

The sun sends much more of the energy that our world needs. Nanotechnological approaches that we can use this energy and also hydrogen energy more efficiently are inevitable that it will have a great impact on our daily life. Classic nanostructures like carbon nanotubes can be used to produce cheaper and more efficient solar energy. Nanoparticles increase the surface area / volume ratio and thereby increase the amount of accumulation of its radiation. Also, the use of nanomaterials causes more electrons to be released when a light strikes the photon. Structural features of PV cells can also be modified using nanotechnology [5].

Hydrogen energy is the most important alternative energy that will replace fossil fuels that are becoming more and more depleted due to its high thermal value and environmental sensitivity. storing high concentrations of hydrogen with existing methods by nanotechnology possible while carrying some of the research carried out by the United States and Turkey partnership shows that it is possible for high density storage of hydrogen [6]. A new and promising field of research is growing rapidly and nanotechnology is considered one of the most recommended options for solving problems in this field.

It seems that the use of nanotechnology is effective in many areas of life due to its interdisciplinary feature.

Potential application areas of nanostructure and nanotechnology are rapidly developing in material production, electronics, pharmacy, medicine, health, energy, chemistry, physics, computer and information technology [7-14]. In this study, it is aimed to give information about the usage of nanotechnology in the field of energy.

2. Using Nanotechnology in the Energy Field

Nanotechnology has provided new possibilities to solve problems that need to be overcome in the field of energy. One of the biggest problems in energy resources today is the lack of alternative energy resources or the efficiency of the resources available cannot be brought to the desired level. Problems arising during the storage and transportation of the energy obtained cause energy losses. In addition, the energy obtained cannot be evaluated efficiently by the users and there is a lot of energy loss during the usage phase. For the solution of these problems, intensive work is being carried out in line with the innovations brought by nanotechnology [15, 16].

Nanotechnology applications have also made progress in the field of energy and have also affected the energy sector with innovations especially in the field of nano-production. The power of nanomaterials, their capability to conduct electricity and their reactivity rates increase significantly. Nanotechnology projects, which have begun to affect the fields of energy consumption and production, especially focus on increasing lighting and heating efficiency, increasing the capacity of electricity storage and cleaning the pollution in energy production. In addition, new generation batteries and capacitors can be defined as important examples of the nanotechnology in the energy sector [17-19].

Today, as a result of increasing energy-fuel consumption, existing natural resources are being depleted rapidly. As a result, the search for alternative energy sources has increased in recent years and significant financial support has been set aside for research on alternative energy sources in developed countries. The most important of these studies is the studies on hydrogen energy. One of these studies is the generator that produces hydrogen fuel and takes its power from light while cleaning the air. Thanks to the nanoparticles in the catalyst of the device, hydrogen gas is produced while cleaning the dirty air [20, 21].

The disadvantage in solar cells is the high production cost reflected in the current high cost of conventional PV cells. The efficiency of solar absorption is also very weak at present, and solely part of energy is converted into electricity. Alternative material such as Ti02, leads to cheaper PV cells, has lower conversion efficiency. Nanotechnology can offer alternative materials and manufacturing techniques to produce acceptable cost-effective PV cells, although there is no higher energy conversion efficiency [5, 22, 23].

Tan et al. examined the advantages of carbon nanotubes in energy conversion and storage, like solar and fuel cells, hydrogen storage, lithium ion batteries, electrochemical super capacitors, green nanocomposite design. They stated that carbon nanotubes will increase their energy conversion efficiency by using solar and fuel cells, which are the future of renewable energy sources [24].

Serrano et al. examined the sustainable energy production and developments of nanotechnology in their study. They stated that nanotechnology can contribute to the production of some materials in the energy sector [17].

According to Savolainen et al., the batteries and supercapacitors can be changed significantly with the application of nanotechnology. The materials could be

designed using nanotechnology to make the corresponding components of lithium-ion batteries heat-resistant, flexible and high-performance electrodes. Thermal energy storage can be better developed by using nano-porerous materials such as zeolites, which can be used as heat stores in both residential and industrial areas [8, 25].

Brinker and Ginger have investigated the ability of nanotechnology for sustainability and energy application. It is stated that reducing energy use is the important process for thermoelectric waste heat recovery devices. It is a fact that these devices have a very low impact on the environment because of the operated completely cleanly and without additional source. It is anticipated that their use in transportation systems will reduce oil consumption [26].

Guo has reviewed renewable energy technologies to utilize future energy for hydrogen fuel, solar cell, nanotechnology and friendly environment [27]. Markovic et al. presented an outlokk of information and communication systems, benefiting from the development in nanotechnology in terms of sustainability and energy efficiency. In the study, it has been stated that the industry has benefited from nanotechnology in any case, along with smart sensors, logic elements, chips, memory devices, applications in optics and computing. Also, nanomaterials have been presented that can be used to increase the capacity of batteries and solar devices [28].

Daryoush and Darvish examined nanomaterial applications for reducing energy consumption. They stated that if nanowires are used in the transmission of electrical energy, the loss of energy in the network and the generated electricity can be reduced. They also stated that nanomaterials can be used in the design of buildings and industrial areas as well as reducing thermal and cooling energy loss caused by electricity consumption [29].

One of the biggest problems in energy resources today is the lack of alternative energy resources or the efficiency of the resources available cannot be brought to the desired level. Problems arising during the storage and transportation of the energy obtained cause energy losses. In addition, the energy obtained cannot be evaluated efficiently by the users and there is a lot of energy loss during the usage phase. For the solution of these problems, intensive work is being carried out in line with the innovations brought by nanotechnology [15,30].

With the help of nanostructures, the band spacing of semiconductors can be adjusted according to the spectrum of the rays falling on the material. In addition, it is ensured that the surfaces of solar cells are coated with nano-structured materials that prevent reflection, thus absorbing more sunlight.

Having cheap, safe and renewable energy sources is the most important issue targeted by all countries worldwide. Solar cells produced with nanotechnology are obtained from cheaper materials and environmental protection is also ensured. The first solar cells made of nano crystals have a very good and efficient structure. Thin film solar cells, which have the opportunity to produce with nanotechnology, find a much wider usage in the buildings compared to the conventional glass panel solar energy systems based on silicon, thanks to their flexible structure. In addition, they can eliminate the aesthetic problems caused by traditional solar cells [31-34].

Insulating materials produced with nanotechnology save 30% more energy than traditional materials. These insulation materials are used by squeezing between solid panels or as a thin film on any surface. The efficiency of fuel cells can be increased by using hydrogen sensors and nanotechnological membranes. Thanks to nanomaterials, the efficiency of wind panels and solar cells is increased. Storage rate can be increased thanks to nanostructures in hydrogen storage. Losses in power transmission lines and transmission cables can be minimized. In addition, energy savings are provided by nanomaterials with high insulation ability [17, 18, 35].

By using nanofluids as coolants, radiator sizes can be reduced and easier positioning can be achieved. Due to their high thermal performance, the amount of working fluid used is reduced, the pump of the coolant system shrinks, and truck engines can be operated at high temperatures to provide higher horsepower. Saidur et al. conducted that the use of nanofluid as a working fluid in radiators may cause a 10% reduction in the volume of the radiator system [36, 37].

Promising thermoelectric devices for energy in which nanotechnology is used provide high accuracy heating and cooling temperature control. These devices, which convert heat into electrical energy by using thermal conductivity, are small in size and simple in structure and do not have mechanical parts. These technologies will find wide application areas with quantum points of thermoelectric materials for cooling purposes, which provide faster processing in computer chips, especially in information technologies. With the nano-robots to be made with nanotechnology, oil deposits will be detected precisely in the near future. All these applications are among the advantages of nanotechnology to obtain energy [38]

Geothermal energy is also powered by nanotechnology. In conventional geothermal power generation, cold fluids are injected into heated hot rocks, about 1500 m below the soil surface. The liquid is then extracted and for generating electrical energy. Nanotechnology is currently to make geothermal energy more practical by providing to production of energy closer to the surface and at suitable temperatures. The heat retention characteristics of the liquid are also increased with nanoparticles [5].

Another source of clean energy is wind energy. Wind energy rotates a turbine to generate electricity. One of the factors affecting the production capacity of these systems is the state

of the system against mechanical loading. By using carbon nanotubes, both lighter and more durable materials can be used in these systems and the efficiency of the system can be increased [16, 39].

Nanotechnology contributes to energy studies to obtain energy resources by applied technologies that offer improved performance, efficiency, savings and security, and will contribute more in the future. Industrialized societies consume a lot of energy for the needs such as transportation, lighting, heating and cooling. By using nanomaterials, the efficiency of lighting and heating devices can be improved, electrical storage features and energy savings can be achieved. More energy can be provided than conventional batteries by using nanotechnological aerogels in the separator plates in the batteries. The charge time of lithium-ion batteries containing carbon nanotubes is shortened and the energy density they provide increases [40-45].

3. Discussion and Conclusion

Sustainable energy production, conversion and use minimizes the impact on the environment. It is very important to provide easy and inexpensive access to energy to the world population, where demand is increasing. Today, when sustainability and energy efficiency have become a necessity, nanotechnological materials can increase the competitiveness of companies. Although sustainability is one of the biggest necessities of our era, it can be provided much more easily within the scope of the possibilities offered by nanotechnology. Nanotechnological building materials support sustainable architecture and have taken their place today with the concept of green nano architecture. In this context, it is aimed to provide sustainable building design supported with nanomaterial. In this way, energy saving structure design will be realized.

One of the areas that will be most heavily affected by nano technology is the energy sector. The fact that fossil fuels will be depleted day by day and air and environmental pollution caused by the use of these resources have intensified the researches in the field of energy production in recent years. Films transform the solar energy into electricity, collector systems and coatings that convert solar energy into heat energy are currently used. With the efficient use of solar energy with nanotechnological approaches, hydrogen, which is a clean energy source, will have a great effect on our life. Hydrogen energy is the most important alternative energy to replace increasingly depleted fossil fuels due to its high thermal value and environmental pollution.

Using nanotechnology in the renewable energy field can play an important effect on increasing the efficiency of solar cell and wind turbine. Nanotechnology can achieve for the developed countries to reduce the environmental impact of fossil fuels to generate energy. Besides the cost of expensive components such as solar cells, nanotechnology makes significant reductions in hydrogen production and storage. Nanotechnology can be considered as the key provider of increased hydrogen energy use. The biofuel industry has evolved greatly using nano-practices. Wind turbine efficiency and the life of the turbines can be improved by using nanoparticles.

As a result, nanotechnology can play an important role in developing countries and increasing the use of alternative energy sources. It can be used, among other things, to improve energy storage and electrical energy transmission. Developing countries need to increase their efforts by investing in nanotechnology research, as they can help them overcome energy challenges.

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