International Journal of Materials Science and Applications
2021; 10(3): 55-60
http://www.sciencepublishinggroup.com/j/ijmsa
doi: 10.11648/j.ijmsa.20211003.12
ISSN: 2327-2635 (Print); ISSN: 2327-2643 (Online)

The Role of Nanotechnology for Energy Storage, Conservation and Post Combustion CO_2 Capture in Industry: A Review

Meselu Eskezia Ayalew

Department of Chemistry, Oda Bultum University, Chiro, Ethiopia

Email address:
mesiphysi2010@gmail.com

To cite this article:
Meselu Eskezia Ayalew. The Role of Nanotechnology for Energy Storage, Conservation and Post Combustion CO_2 Capture in Industry: A Review. *International Journal of Materials Science and Applications*. Vol. 10, No. 3, 2021, pp. 55-60. doi: 10.11648/j.ijmsa.20211003.12

Received: April 5, 2021; **Accepted**: April 23, 2021; **Published**: June 21, 2021

Abstract: Nanotechnology is referred to as the science of nanoscale which is objects that range in nanometers in size. The use of nanomaterials in energy conversion and storage represents an opportunity to improve the performance, density and ease of transportation in renewable resources. Energy is an unavoidable theme in contemporary society, ranging from basic daily life to superior science and technology. Over increasing energy demand and always deteriorating environmental issues, electricity has turn out to be bottleneck and is hindering the development of society. The use of nanotechnology to increase a suite of sustainable power manufacturing schemes is one of the most necessary scientific challenges of the 21st century. The challenge is to design, to synthesize, and to represent new useful nanomaterials with controllable sizes, shapes, and structures. And also now a day's a serious interset is required to reduce the level of CO_2 the use of advanced and environment friendly CO_2 seize technologies. Carbon dioxide seize and storage (CCS) applied sciences can also play an necessary function in this direction. Nanotechnology is used to seize CO_2 formore than a few industrial processes. This review is ordinarily centered on the role of nanotechnology in the electricity storage, conservation and post-combustion CO_2 absorption process. The features of nanomaterials and nanoparticles have been studied in the current work.

Keywords: Carbon Dioxide Capture, Energy Storage, Nanomaterials, Nanotechnology

1. Introduction

Now a day, our society faces a serious electricity crisis due to increasing human population. Energy consumption begins from small-scale electronic devices to high power eating electric vehicles. To provide power on demand, researchers focus on alternative renewable power sources such as, as photo voltaic cells, gasoline cells, secondary batteries and supercapacitors are current global issue. The strength energy conversion and storage technologies such as solar cells, fuel cells, secondary batteries and supercapacitors are current global issue. The energy conversion and storage performance of those applied science rely on fabrics homes of their electrode, electrolyte, and other system components. The asepcts of nanostructuring machine lead to more desirable effectivity in terms of robustness and reliability of the energy conversion and storage structures [1].

Nanotechnology is referred to as the science of nanoscale which is objects that range in nanometers in size. Nanotechnology can be described as the use of nanomaterials for human benefit. Nanomaterials have unique properties due to their physical and chemical characteristics at the nanoscale (10^{-9} nm) [2]. Nanotechnology can be the feasible solution to the problems which are associated to humans having to do with the vital want and wishes for sustainable living. The vital needs of humans are food, water, energy, clothes, shelter, health and clean surrounding conditions. The needs for lavish life include understanding and achieving computerization in each and every field such as space travel, increasing life expectancy [3]. Nanotechnology is viewed as a transformative science that has the potential to stimulate scientific innovation while greatly benefiting society. Nanotechnology is applicable to the development of new materials and units in many fields that reveal nanostructure-dependent houses [4].

2. Nanomaterial and Nanoparticle

Nanomaterial is a fabric with any exterior dimension in the nanoscale or having inside shape or floor structure at the nanoscale, which ought to show off novel characteristics compared to the equal fabric barring nanoscale elements [5, 6].

Nanomaterials can be classified into organics and inorganics, which have been concluded from. Organic nanomaterials consist of fullerenes, carbon nanotubes, single-walled carbon nanotubes, multi-walled carbon nanotubes, graphite and nanofibers. Most of the organic nanomaterials are carbon based nanomaterials [7]. Nanoparticle is a particle that has all its three dimensions on the order of 100 nm or less, and may also be referred as nano-object [3].

Nanoparticles with sizes under 20 nm are these for which the bodily houses may additionally vary greater considerably in comparison withthe conventional measurement materials.

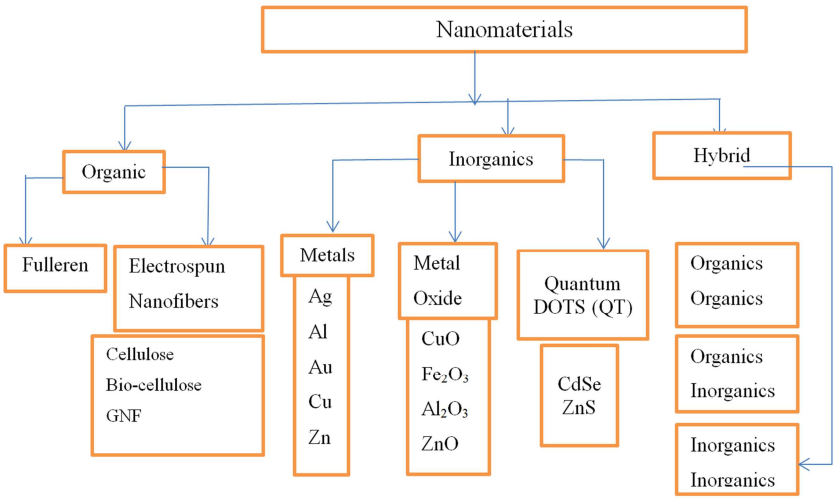

Figure 1. *Classification of nanomaterials [3].*

2.1. Nanomaterials for Energy Conversion

Energy production and storage is one of the fundamental challenges of the twenty first century. Increasing energy needs coupledwith growing materials shortage has inspire the search for new materials for energy science development. Nanomaterials are a great class of materials to power this innovation due to their emergent properties at the nanoscale [8]. The use of nanomaterials in energy conversion and storage represents an opportunity to improve the performance, density and ease of transportation in renewable sources [9]. Recently, the role of nanostructured substances in addressing the challenges in energy and natural sources has attracted extensive attention. In particular, oriented nanostructures exhibit promising properties for strength harvesting, conversion, and storage [10]. One of the most interesting and most flexible renewable energy technologies is the direct conversion of sunlight into electric powered power: the photovoltaic effect. Carbon NMs, together with C60 fullerenes, carbon nanotubes and graphene have been studied as extraordinarily environment friendly electron acceptors in polymer and quantum dot solar cells. Relatively new, dye sensitized photo voltaic cells are of brilliant promise. In these devices, a nanocrystalline mesoporous titanium dioxide (TiO_2) film, with a monolayer of the charge switch dye attached to its surface, is pasted on a obvious conductive substrate. The giant NM surface location for dye chemisorption and the quick charge migration length underlie their electricity conversion efficiency. In addition to solar cells, nanotechnology has made massive have an effect on on gas cells, devices capable to convert chemical power without delay into electricity. Nano-porous metals with excessive surface area, low unique densities and wealthy floor chemistry, can be incredibly efficient electro-catalysts for the necessary electrode oxidation/reduction reactions in gas cells. Platinum nanoparticles (Pt-NPs) have been regarded as the exceptional mobile phone catalyst, even though the Pt-based electrode suffers from time-dependent float and carbon monoxide deactivation [11].

2.2. Nanomaterials for Energy Storage

A sustainable power provides requires a stepped-up alternate to renewable sources of power [12]. Energy storage performs necessary roles in conserving the over demand of strength for utilization all through the demand. On the other hand, many sorts of energy sources are intermittent in nature like photo voltaic power which is affected through cloudy and dusty weather, as nicely as the non availability in the course of the night [7]. Energy storage consists of a wide vary of applied sciences and functions and is categorized in accordance to the way in which the electricity is stored.

1) Chemical energy: accumulator, battery, redox flow battery, hydrogen, methane
2) Mechanical energy: flywheel, spring, pumped-storage power plant
3) Electrical energy: capacitor (electrical engineering), superconducting magnetic energy storage.
4) Thermal energy: warmness accumulator

The storage of electrical energy is rather complex. It must first be transformed into every other shape of energy, which is associated with loss. Nanotechnology innovations are

already contributing to expanded energy conversion, storage and transmission [12].

Nanotechnology may additionally have a profound have an impact on electrical storage technologies, i.e. batteries and electrochemical supercapacitors. Redox-based supercapacitors with nano-structured electrode materials have proven the possible to mix the excessive energy density of traditional batteries with the high electricity capabilities of electrostatic capacitors at the lab scale. Concerning rechargeable lithium batteries, the energy densities and the performances of these gadgets mostly rely on the bodily and chemical houses of the electrode material. In this regard, the decreased dimensions and high floor vicinity of NMs expand the charge of electron transport and the electrode-electrolyte contact, respectively, whilst the nano-structure itself affords facile pressure leisure and resistance to fracture. For anode applications, CNTs, a series of graphene-based nanostructures and silicon nanowires have been studied as promising host-high capacity materials and conductive additives [11].

2.2.1. Battery, Accumulator, Capacitor

Batteries shop electrical electricity in the shape of chemical energy. All batteries work on the same principle: batteries are made up of two electrodes linked to a circuit. The "positive electrode" (cathode) is the electrode that takes up electrons when the battery is connected to a load. The "negative electrode" (anode) is the electrode that offers off electrons when in operation. A chemical response on the anode creates electrons whilst the chemical response on the cathode uses electrons. The reactions create an electrical current. A battery is recharged via reversing the electrical circuit in which an externally applied charge forces the electrons in the contrary direction. Batteries today are understood to be both essential as properly as rechargeable secondary cells. A secondary phone is additionally referred to as an accumulator. "Rechargeable battery" or "secondary battery" is extra regularly used in vicinity of accumulator. Due to the chemical reactions that take vicinity at some point of the charge-discharge cycles, structural modifications take place in the electrode materials of the battery, limiting the range of recharge cycles [12].

A capacitor, particularly the electrolytic capacitor, is an electrical component in which the electrolyte serves as the cathode and for this reason the second electrode. The capacitor stores electrical strength in an electrical discipline between the capacitor plates.

Capacitors can be charged and discharged extra than several million times except any sizeable trade in the materials. The various kind of energy storage will be more closely examined:

1) Lithium-ion battery
2) Lithium-air battery / Sodium-air battery
3) Lithium-sulphur battery / Sodium-sulphur battery
4) Printed battery
5) Supercapacitor
6) Nanocapacitor
7) Metal hydrid storage

2.2.2. Nanotechnology in Industrial Sector

Nowadays, nanotechnology is offering new merchandise in all industrial sectors [2]. anotechnology is impacting the sphere of products, a number of merchandises that contain nanomaterials are already during a kind of items; many of that human beings do not even observe contain nanoparticles, merchandise with novel functions ranging from easy-to-clean to scratch-resistant. samples of that car bumpers are created a lighter, commodity may also be a ton of stain repellant, the ointment can also be a ton of radiation-resistant, artificial bones are stronger, telephone monitors are lighter weight, glass packaging for drinks land up at some stage in an extended shelf-life, and balls for a number of sports activities are created heaps of long lasting [3].

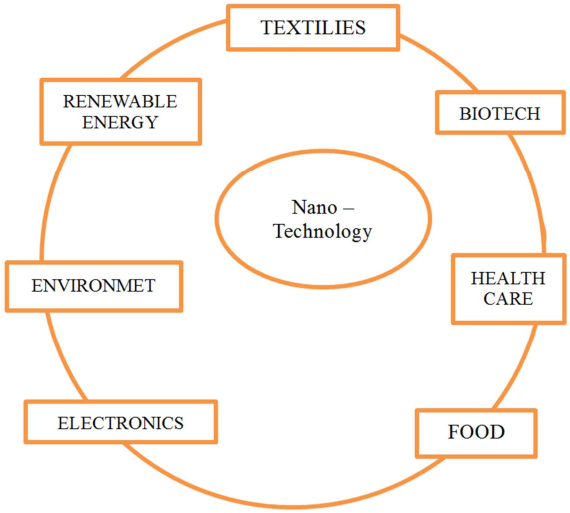

Figure 2. *Various fields affected by Nanotechnology.*

2.3. Biomedical Applications

Nanoparticles are used for disorder diagnosis, drug delivery, gene remedy of cancer, pulmonary illnesses and prevention of different infections also. Cancer is malignant neoplasm, and there is uncontrolled division of cells which enter into everyday adjacent tissues and spoil them [2].

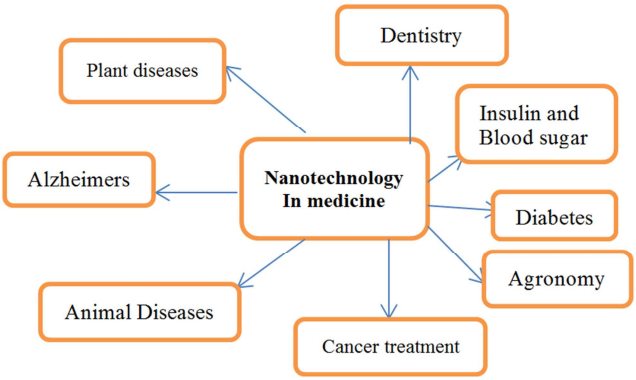

Figure 3. *Medical cases in which Nanotechnology is used.*

2.3.1. Nanotechnology in Agricultural and Food Production

A range of nanomaterials, usually metal-based

nanomaterials and carbon-based nanomaterials, have been exploited for their absorption, translocation, accumulation and consequences on growth and improvement of crop plants. The nice morphological consequences blanketed more desirable germination share and rate, length of root and shoot, their ratio and vegetative biomass of seedlings in many crop plants [5]. Nanotechnology is becoming popular in several fields like electronics, robotics, medicine, etc. However, it has been much less famous inside the food area as compared to different fields. Most vital applications in this zone are meals processing, meals packaging, food preservation, and food best monitoring [3].

Food Processing: Food processing is the formation of food merchandise from uncooked ingredient using suitable operations. Processing of meals includes a range of steps-removals of toxic substances, protection from pathogens, protection of food, growing the shelf life, improving the colour, texture, odour of meals etc. Nowadays, all these strategies are made extra wonderful via the usage of nanotechnology.

Antimicrobial Packaging

Barriers are made of nano-sized particles to inhibit microbial growth up to a certain level which may lead to food spoiling. Generally, nanoparticles in such kind of packaging are made of silver. Silver nanoparticles have the ability to inhibit and control the development of bacteria. Compounds like zinc oxide have antimicrobial nature which proves to be a vital factor in nanotechnology. Titanium dioxide can be used as a coating material in packing material to prevent the growth of bacteria.

Food Quality Monitoring

Nanosensors are materials of nano-size used ordinarily for the detection of pathogens or contaminants in food. Nanosensors have very excessive sensitivity. The benefit of nanosensor machine is that hundreds of nanoparticles are frequently positioned on one sensor for correct detection of the presence of pathogens internal saved grain bulk in boxes and can also be arranged and disbursed into the gaps of grain bulk.

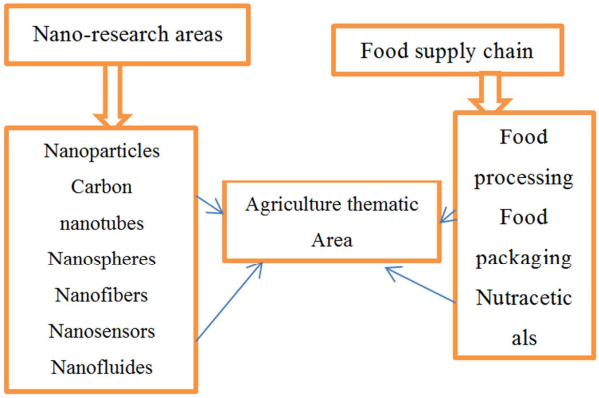

Figure 4. *Agricultural Thematic Area Table.*

2.3.2. Nanotechnological Applications in Agrowaste Reduction and Biofuels

Cellulose-based nanomaterials have been used as conceivable nanoreinforcing filler into biocomposites for industrial and biomedical applications. Nanomaterials such as calciumoxide and magnesium oxide nanoparticles have been used as biocatalyst carriers in oil transesterification to biodiesel [2].

2.3.3. Nanotechnology in the Textile Industry

Nanotechnology is utilized in cloth industry due to the expanded sturdiness of fabrics, comfortness, hygienic homes and decreased manufacturing cost. The pleasant homes of nanoparticles can provide excessive durability for handled fabrics as they possess large floor region and excessive floor energy that make certain better affinity for fabrics and led to an make bigger in sturdiness of the favored fabric function. The use of nanotechnology approves textiles to end up multi-functional and produce fabrics with distinct functions, inclusive of antibacterial, UV protection, convenient clean, water and stain repellent and antiodor [3].

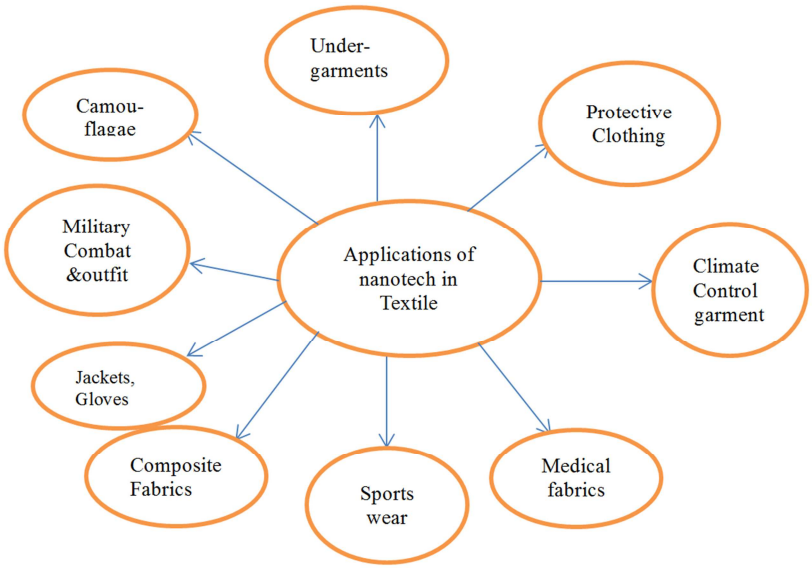

Figure 5. *Applications of Nanotechnology in Textile Industry.*

2.4. Nanotechnology on Post-combustion CO_2 Absorption in Process Industry

To amplify in worldwide carbon dioxide emission and its unfavourable affect on the environment have created several pressing challenges for human beings throughout the world. The varieties of international locations are competing with each other to fulfill the target of being developed international locations in the complete world. So, the increasing set-up of large-scale industries, factories and companies are going on in a continually unfavourable manner ignoring the environmental concerns. At present, the whole population is critically subjected to oil-based commodities in which coal, flamable gases and crude oil make a contribution about 41, 21 and 5%, respectively, and their consumption raises the stress of climate destabilization prompted by growing carbon dioxide (CO_2) launch in the air. Carbon capture and storage is the latest and efficient innovation presently utilized to trap CO_2 and store it for beneficial purposes [13].

2.5. Carbon Dioxide Capture Techniques

Carbon seize and storage is the system in which CO_2 is separated out from diverse technique industries working at high temperatures the use of various solvents in columns and injected deep below the ground. After that, it is transported to storage and thereby decreasing GHG emissions. Three simple methods are used to capture CO_2, viz, pre-combustion, post-combustion and oxy-fuel combustion. Researchers have already provided an overview of CO_2 capture and storage technologies. Thermo-physical residences related to carbon capture device format for the duration of operation have been additionally reviewed. The post-combustion decarbonization is the technique primarily based on the CO_2 separation that occurs after gasoline combustion. The important cause of oxy-fuel combustion is to cast off inert gases from the combustion of flue gases. In this method, to obtain whole combustion, the firing of the gasoline is performed only with oxygen. This leads to the formation of a high attention of CO_2 and minor quantities of water vapor at some stage in combustion

2.6. The Role of Nanoparticles and Nanomaterials in CO_2 Capture

At present, nanotechnology has attracted researchers in the direction of its utilization in numerous electricity systems. The CO_2–nano-fluid gadget can also play a critical function in controlling pollution. The extend in global CO_2 emissions and their influence on environmental air pollution have created a lot of challenges to the atmosphere. Different researchers reviewed a number of absorption and adsorption technologies to capture CO_2, and various low-cost regeneration strategies for CO_2- loaded adsorbents had been proposed. The position of nanomaterials and nanoparticles is currently taking part in an important function in CO_2 capturing-related technologies. The researchers are working with nanomaterials to decorate the effectively of existing applied sciences [13].

3. Conclusion

Nanotechnology is an emerging science with large functions and possible benefits. This evaluate summarizes the function of Nanotechnology for Energy Storage, Conservation, biomedical application, industrial application, food industry and submit Combustion CO_2 capture in industry. The existing assessment has given similarly evidence to this problem and it has tried to address what all the potential environmental influences of the science may be. Although the use of nanotechnology in every and each field is endless and still in its infancy stage, we want a set of legal guidelines which will govern the way nanotech will be used in addition in future.

References

[1] Balasingam, S. K., Sivalingam Nallathambi, K., Abdul Jabbar, M. H., Ramadoss, A., Kamaraj, S. K., & Kundu, M. (2019). Nanomaterials for electrochemical energy conversion and storage technologies.

[2] Singh, N. A. (2017). Nanotechnology innovations, industrial applications and patents. *Environmental Chemistry Letters*, *15* (2), 185-191.

[3] Wang, X. et al. (2008) Application of nanotechnology in cancer therapy and imaging. CA Cancer J. Clin. 58, 97–110.

[4] Kannan, A. M., & Munukutla, L. (2007, January). Application of nanotechnology for energy conversion and storage. In *ASEE Annual Conference and Exposition, Conference Proceedings.*

[5] Santos, C. S., Gabriel, B., Blanchy, M., Menes, O., García, D., Blanco, M.,... & Neto, V. (2015). Industrial applications of nanoparticles–a prospective overview. *Materials Today: Proceedings*, *2* (1), 456-465.

[6] Green, C. J., & Ndegwa, S. (2012). *Nanotechnology: A review of exposure, health risks and recent regulatory developments*. National Collaborating Centre for Environmental Health.

[7] Al-Kayiem, H. H., Lin, S. C., & Lukmon, A. (2013). Review on nanomaterials for thermal energy storage technologies. *Nanoscience & Nanotechnology-Asia*, *3* (1), 60-71.

[8] Hynek, D. J., Pondick, J. V., & Cha, J. J. (2019). The development of 2D materials for electrochemical energy applications: A mechanistic approach. *APL materials*, *7* (3), 030902.

[9] Zhang, Q., Uchaker, E., Candelaria, S. L., & Cao, G. (2013). Nanomaterials for energy conversion and storage. *Chemical Society Reviews*, *42* (7), 3127-3171.

[10] Liu, J., Cao, G., Yang, Z., Wang, D., Dubois, D., Zhou, X.,... & Zhang, J. G. (2008). Oriented nanostructures for energy conversion and storage. *ChemSusChem: Chemistry & Sustainability Energy & Materials*, *1* (8-9), 676-697.

[11] Iavicoli, I., Leso, V., Ricciardi, W., Hodson, L. L., & Hoover, M. D. (2014). Opportunities and challenges of nanotechnology in the green economy. *Environmental health*, *13* (1), 1-11.

[12] Yaroslavtsev, A. B., Stenina, I. A., Kulova, T. L., Skundin, A. M., & Desyatov, A. V. (2019). Nanomaterials for electrical energy storage. In *Comprehensive nanoscience and nanotechnology* (pp. 165-206).

[13] Kumar, R., Mangalapuri, R., Ahmadi, M. H., Vo, D. V. N., Solanki, R., & Kumar, P. (2020). The role of nanotechnology on post-combustion CO_2 absorption in process industries. *International Journal of Low-Carbon Technologies*, *15* (3), 361-367.