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The Application of Nanotechnology against Humidity in the Building Preservation of Tabriz Historical and Traditional City, Case Study: Blue Mosque, Tabriz

Elham Kazemi[1], Mohammad Amin Khojasteh Ghamari[2*] and Shokuh Neshanifam[3]

[1] M.A. of Architecture, Department of Architecture and Art Young Researchers and Elite Club, Tabriz Branch Islamic Azad University, Tabriz, Iran.

[2] Ph.D student of Architecture, Department of Architecture and Art Young Researchers and Elite Club, Tabriz Branch Islamic Azad University and Faculty Member of the Department of Architecture, Institute of Higher Education Roshdiyeh, Tabriz, Iran.

[3] M.A. of Architecture, Department of Architecture and Art Young Researchers and Elite Club, Tabriz Branch Islamic Azad University, Tabriz, Iran.

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ABSTRACT: Since historical monuments carry national values and identity, their maintenance and protection is necessary through methods which provide holistic stability and originality preservation. Nanotechnology creates the possibility of monitoring the intrinsic traits such as melting temperature, magnetic properties, and load capacity. The colour of materials could even satay changeless in their chemical composition by developing some structures in Nano-meter scale. This means that fewer materials with better quality will be required for a determined function. In this research, it is tried to present solutions for removing deficiencies and damages of historical monuments by application of nanotechnology. Humidity is the main cause of historical monuments damages. Although current insulators prevent penetration of humidity, but they remove adobe and stone surfaces respiration and cause new problems. In this research, it has been tried to provide building respiration by application of nanotechnology and insulators produced by this technology. Religious monument of Blue Mosque is one of the valuable phenomena that relate to the period of Garagounlu. The outstanding feature and publicity of this mosque relies on wonderful and combinatory architecture and mosaic and combination of adobe and tile and solid motives that ornamented the monument interior and exterior surfaces. By selection of case study of Tabriz Blue Mosque, it was tried to investigate nanotechnology performance in this monument based on the region climate and used materials. The research will then present solutions for sections damaged by natural disasters through author laboratory analyses and descriptive and analytical methodologies to preserve this valuable monument in Tabriz architecture history.

Keywords: Historical Monuments, Repair, Nanotechnology, Materials, Humidity.

INTRODUCTION

Buildings are sensible energy and material consumers, and energy plays an important role in stability of the settlements. Nowadays, the architects' challenges are designing and promoting the buildings with less energy consumption and less environmental damages on the natural resources and environment. Historical monuments involve cultural, historical and architectural national values which are considered as an effective model for current designs. Repairing and survival of this heritage is a way for preserving values. Humidity is the main cause of damages in historical monuments. Although current insulators prevent penetration of humidity, they remove adobe and stone surfaces respiration and cause new problems. In this research it has been tried to provide building respiration by introducing nanotechnology and insulating the surfaces by this technology. How can we have inspirable insulator surface with nanotechnology? How is the performance of the nanoparticles on hydroxyl surfaces? And in what conditions the Nano-products are used? Are the questions which were tried to respond

* Corresponding author email: Khojasteh.tu@gmail.com

in this research in order to find proper solutions from theoretical point of view. Comparative and analytical method was used in this research, besides using related resources and author's experimental studies. A practical method has been proposed for having insulator materials with capability of respiration by explaining the problems and deficiencies of the common insulators, polymers and resins, besides explaining the nanoparticles performance on surface molecules and expressing the materials surface hydrophobic. A group of products and their characteristics was introduced and their chemical reactions in formation of bound with building materials were shown. Finally, by confirmation of this approach and accepting nanotechnology as an optimal and new achievement in repairing the surfaces and having hydrographic materials, it was planned to analyze these materials before use and examine them by field and laboratory tests, and conform them to considered materials' properties and country environmental and climatic conditions. Nanotechnology products and materials have been used extensively in repairing of the monuments, paintings, graphics and surfaces in recent ten years. In this article nanotechnology has been studied as case study in different parts of Blue Mosque repairing plan (Mohamed Hazem, 2010 & Jim, 2007).

NANO

What's Nano?

Nano is a prefix in the International System of Units denoting a factor of 10−9. The prefix is derived from the Greek "νᾶνος", meaning dwarf, and was officially confirmed as standard in 1960. When used as a prefix for something other than a unit of measure, as in Nano-science, "Nano" means relating to Nano- technology or on a scale of nanometers (Anous, 2014, p. 17).

Nano Scale

The "Nano scale" is typically measured in nanometers, or billionths of a meter, and materials built at this scale often exhibit distinctive physical and chemical properties due to quantum mechanical effects. To put that scale in another context; the comparative size of a nanometer to a meter is the same as that of a marble to the size of the earth (Anous, 2014, p. 17). The principal parameters of nanoparticles are their shape (including ratio aspect where appropriate), size, and the morphological sub-structure of the substance. Nanoparticles are presented as an aerosol (mostly solid or liquid phase in air), a suspension (mostly solid in liquids) or an emulsion (two liquid phases). In the presence of chemical agents (surfactants), the surface and interfacial properties may be modified. Such agents can indirectly stabilise against coagulation or aggregation by conserving particle charge and by modifying the outmost layer of the particle. Depending on the growth history and the lifetime of a nanoparticle, high complex compositions, possibly with complex mixtures of adsorbents, have to be expected. In the typical history of a combustion nanoparticle, for example, many different agents are prone to condensation on the particle while it cools down and exposed to different ambient atmospheres. Complex surface chemical processes are to be expected and have been identified only for a small number of particulate model systems. At the nanoparticle - liquid interface, polyelectrolytes have been utilised to modify surface properties and the interactions between particles and their environment. They have been used in a wide range of technologies, including adhesion, lubrication, stabilization, and controlled flocculation of colloidal dispersions (Liufu et al., 2005, pp. 33-40). At some point, between the Angstrom level and the micrometre scale, the simple picture of a nanoparticle changes as a ball or droplet. Both physical and chemical properties are derived from atomic and molecular origin in a complex way. For example the electronic and optical properties and the chemical reactivity of small clusters are completely different from the better known property of each component in the bulk or at the extended surfaces. Complex quantum mechanical models are required to predict the evolution of such properties with particle sizes, and typically very well defined conditions, to compare experiments and theoretical predictions (Singh, 2010, p. 4).

Nanotechnology (NT)

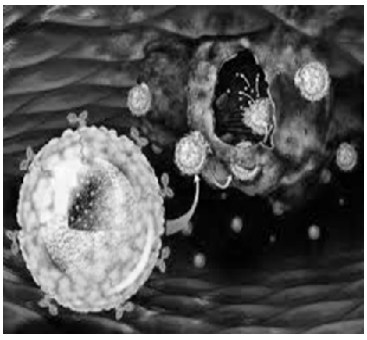
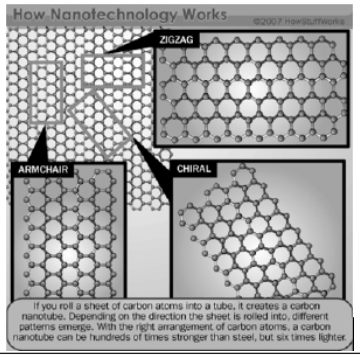
Nanotechnology, shortened to "nanotech", applies the new knowledge developed through Nano-science in the design of new products. It is a new approach related to the understanding and control of material properties. It deals with structures of the size of 100 nanometers or smaller in at least one dimension, and involves developing materials or devices within that size. At this level, the substance exhibits differently and often through surprising properties. Due to its properties and resultant advantages, this technology has run its course in all fields of life (Anous, 2014, p. 16). Nanotechnology offers a reduction in the consumption of raw materials and energy, reduced CO2 emissions, conservation of resources, greater economy and comfort (Leydecker, 2008). The applications of nanotechnology are in all aspects of our life, it can be pertained in medicine, industry, communications, transportation, and more important, architecture (Maged Fouad, 2008).

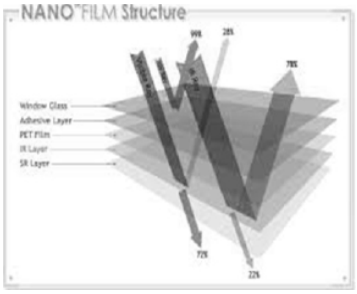
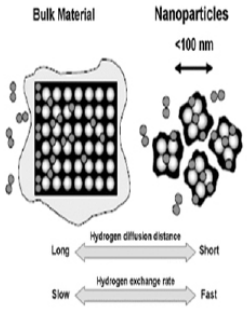
Nano- architecture (Nanotechnology and Architecture)

Nano architecture combines nanotechnology with architecture and its versatile effects. It is concerned with the influences of the discovery of nanotechnology on architecture and interior design as well as on the thought of the architect and interior design. Nano architecture will allow designs to interact better with the human senses (Anous, 2014, p. 17). The architect John M. Johansen is creating unique perspectives on how we will fuse new technologies with build form (Anous, 2014, p. 17). He brings up a few very important points about what Nano-architecture can bring: Making the Technology More Humane: Nano-architecture will allow designs to have better interact with the human senses. Buildings that will "Grow": It is interesting to think of architecture as a "growing" environment that evolves according to different respective codes, Responsive Architecture means that Personalization of Nano-architectural spaces will be a likely benefit giving occupants greater flexibility and choice. It means that using of Nano-technology architecture helps the Buildings to achieve technology progress and provide more comfort for people. Bringing Architecture Closer to Nature illustrates that Nano-architecture will bring architectural design a few steps closer to having buildings which are more synchronously harmonized with nature (Anous, 2014, p. 17). Good design, in principle, is always based on demand and therefore, contributes to the evolution of both Nano-materials and the resulting Nano-product in long term. The materials and products for which there is a demand will become established whereas others will disappear from the market (Leydecker, 2008).

Classification of Nano-materials (Table 1)

Table 1. Classifications for Nano Materials

Types	Explanation	Picture
Nanoparticles	Nanoparticles, also called "zero dimensional Nano-materials", do not possess dimensions outside the 1-100 nm range. Although nanoparticles can have different shapes, crystal structures and compositions, their small scale induces a change in fundamental properties (Dabbousi et al., 1997).	
Nanowires and Nanotubes	Nanowires and nanotubes are materials created with one non-Nano dimension. These materials tend to have one long axis (above 100 nm), and a cross-section that is within the 1-100 nm range. The best examples of these structures are the widely publicized carbon nanotubes (Iijima, 1994).	

Nano Films	Nano films are materials that have two non-Nano dimensions. Typically, Nano-films are used as a surface treatment when composition or/and mechanical properties need to be altered, or as coatings, when a different material is deposited to create a new surface (Kotov, 2001).	
Bulk Nano-materials	Bulk Nano-materials are materials that have Macro-dimensions in 3-D, but exhibit a Nano-scale substructure. Currently, there are two main processes used to achieve bulk Nano-materials production of nanoparticles in powder form, followed by high-pressure compaction and subsequent high temperature sintering to consolidate the powder) high angular extrusion or high pressure torsion, where relatively small metal work pieces (of the order of cm) are highly deformed to produce a Nano-scale substructure (Sanders, 1997).	

APPLICATION CASE STUDY OF NANO-TECHNOLOGY IN REPAIRING

Body of the historical monuments in historical fabric of Naraq: One of the historical monuments was insulated with cost of 20 million Rials. In addition to hydrophobia and sun ray resistance, there is the possibility of writing on the historical monument and the monument can breathe easily. Insulating was done by a new Nano product built on a silt pillar with life between 10 to 15 years under specific conditions (URL1, 2015).

Historical Monuments and Humidity Damages

Humidity is an important damaging factor that duplicates energy loss in building. Wear out materials increases humidity damages in the historical monuments. Humidity enters the building by different ways. Significant part of humidity penetrates by rainfalls and statured particles in the space that approximately is found near these buildings and threatens their health. Insulating historical monument surfaces is the common way to prevent this damage. Nowadays, many insulators including traditional materials, like thatch and polymeric insulators, and different processed resins are used in a way that in all of them, except for thatch, the building surface wouldn't be able to breathe. Prevention of air flow in the materials, particularly in adobe, brick and thatch as main historical materials, causes weakling, corrosion and rapid destruction of the building (Gollabchi, 2012).

Insulator Particles Performance on Materials Surfaces

All masonry materials in different dimensions have pores with different sizes. One of the main factors in humidity, vulnerability, absorbency and non-absorbency of a surface is porosity. Since, the masonry materials' surfaces are similar to hydroxyl stone, due to hydroxyl property and similarity with H2O, the hydrophobic property is increased. When an unprotected building is exposed on a squall with velocity of 32 hours in an hour, it absorbs more than ten liters water for each m^3 in six hours (www.iranicaonline.org). Water penetrates when it makes a hydrogen bond or non- hydrogen bond with a surface, and if it lacks, the property would not make bond among hydrophilic surfaces as the surface with OH group. The size of the holes of these surfaces are in the ranges of 5 to 200 nm, while the H_2O molecule size is 0.018 nm and the size of chloride, acids and sulfates particles are between the ranges of 1 to 2 nm. Thus we find that the water, chloride, acids and sulfates particles penetrate into holes easily (URL3, 2015).

Nano- insulator Performance Adjacent to Brick or Stone

These substances function allows Nano-particles to cover the surface on the walls and finally, the walls and interior and exterior surfaces are covered. This phenomenon causes the formation of new bond that reduces the materials hydrophilic property and leads to hydrophobic surface, or in other words, H_2O molecule absorption is prevented by holes' tension. There is possibility of respiration and the air molecules are exchanged easily in the inside and the outside area. (Fig. 1, 2) (Espargham & falah amini, 2011, p. 4).

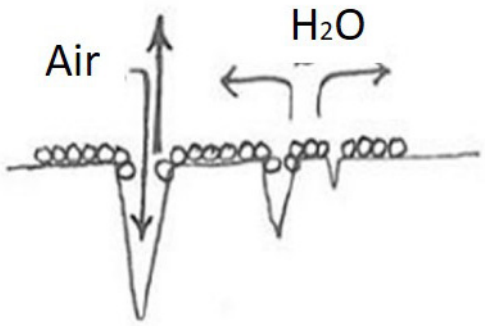


Fig. 1. Nano- particles Adjacent Surface

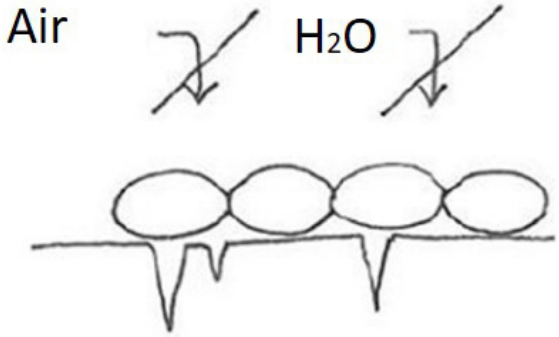


Fig. 2. Nano- particles Adjacent Surface

CASE STUDY: BLUE MOSQUE AND NANO-TECHNOLOGY

Historical

The Blue Mosque is a famous historic mosque in Tabriz, Iran. This Mosque was built during the rule of the Qarā Qoyunlu dynasty (1351-1469) and completed in 1465. It illustrates the artistic brilliance of Turkman era in Tabriz. The extant tile work documents an artistic connection with contemporary architecture of Timurid Khorasan and the Ottoman Empire (URL2, 2015).

It's stone foundation supports a structure of fired bricks, which is completely covered with tiles and decorated fired brick panels. Jean-Baptiste Tavernier observed an alabaster slabs which created a warm red light inside the building .The Blue Mosque seem to fit better into Ottoman rather than Iranian architecture.

Climate

Tabriz is capital of East Azerbaijan province, located in 46 degree and 25 minutes of east longitude and 38 degree and 2 minutes of north latitude from Greenwich meridian. Tabriz height is 1340 meter from sea level (URL4, 2015). Winter is cold and long in Tabriz, and the ground is covered with snow and ice for several months. The precipitation is low in the summer and occurs mostly, as snow, in the winters. According to temperature information in Tabriz, it is clarified that the weather is cold and very cold in 62% of the time, hot in 17% and temperament in 21% of the time (Shagagi, 2000, p. 106).

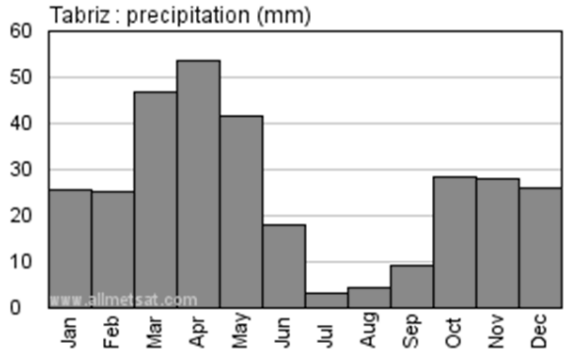


Fig. 3. Precipitation is Water of any kind which Falls from the Sky as Part of the Weather. This Includes Drizzle, Rain, Hail, Sleet, or Snow. Mm/inch

SELF-CLEANING: LOTUS-EFFECT COATINGS AND ITS APPLICATIONS IN NANO-MATERIALS OF INTERIORS

The leaves of Lotus plants are coated with minute wax crystals around 1nm in diameter which repel water; droplets falling onto them bead up and, if the surface slopes slightly, will roll off. Lotus effect is one of the best-known means of designing surfaces with Nano-materials. Self-cleaning behavior is normally achieved using hydrophobic surfaces with nanostructured features fig. 1. These are inspired by the Lotus flower leaves that combine a surface roughness, at a Nano-scale, and water repellent wax. It can be engineered, or mimicked, using Nano-composite materials made up of nanoparticles in a polymeric matrix (Fig. 4) (Anous, 2014, p. 18).

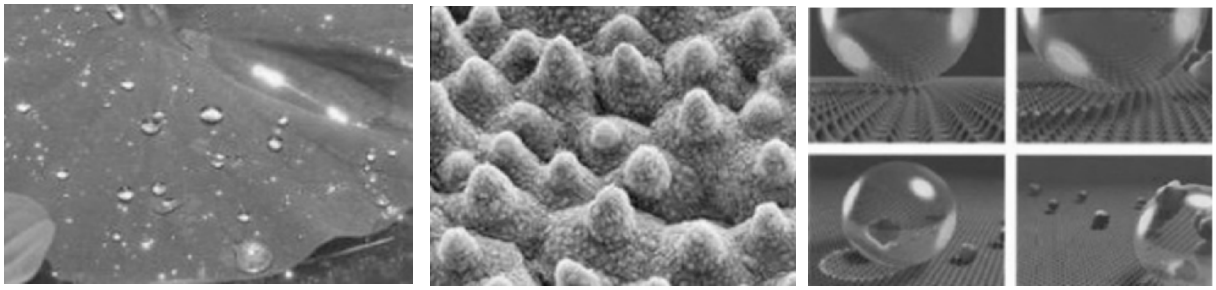


Fig. 4. Lotus Plant, a Microscopic View of a Water Droplet resting on a Super Hydrophobic Knobby Surface and How the Basic Principle of The Lotus-effect Works.

Nano-Coating Paint

The first commercial made product was a silicone resin house paint which became widely used and by which, the silicon nanoparticles formed a micro-structured surface. Nano-coatings can be anti-graffiti, anti-static, anti-mist or anti-glare or they can block UV light. The Commercial Building, Pula, Croatia (Fig. 5) is an example for the use of the self-cleaning Lotus Effect applied on a building surface for a better optimal use and low maintenance façades. The mentioned self-cleaning coating is Lotusan,

which is a self-cleaning paint manufactured by the German company Sto painting (specializing in technical solutions for external insulation). The intensity of pure white surfaces is protected against dirt with the help of a Lotus-Effect facade coating. Dirt simply washes off the rough surface with the rain. The self-cleaning function should persist for at least five years without needing to be renewed. The paint is based on the resin of siloxane. After 24 hours of drying, the paint StoLotusan forms Nano roughness (as a micro structured surface like the lotus leaf) visible in the electron microscope at high magnification because of the siloxane resin .It has been invisibly integrated into the white surfaces to ensure the durability of their color. Painting keeps a matte appearance and limits the effects of pollution. It is very useful on buildings which are usually exposed to rain and tend to get dirty easily, such as in the city, where urban pollution creates black particles on the facades of buildings. This painting-siloxane is more expensive than a normal acrylic paint which pollutes the environment. This painting should not be used in indoor areas because of its self-cleaning ability. Infact, it must be in direct contact with UV rays (Anous, 2014, p. 18).

Fig. 5. Self-cleaning Lotus Effect Applied on a Building Surface for better Optimal Use and Low Maintenance of Façades.

Nano-coating for Wood

It provides complete protection against sunlight and moisture. It preserves the natural look of the wood and is resistant to extreme environmental conditions such as very cold weather and snow. It repels pests and can be applied on both old and new surfaces in a simple, convenient and efficient application. For wood Furniture, walls and similar surfaces; we can apply Nano wood sealant and saturation by spraying, i.e. with airless machines, HVLP-machines, or with brushes and paint brushes. Sealant is fabricated from silicone, wax and oil. By creating nanostructures similar to those of the Lotus plant on the surface of the wood, the contact area between water & wood is minimized and surface adhesion is reduced. Water rolls off instead of penetrating the wood. Researchers at German chemical company BASF are developing a spray-on coating which has made the surface extremely water-repellent (super hydrophobic). BASF's lotus-effect aerosol spray combines nanoparticles with hydrophobic polymers such as polypropylene, polyethylene and waxes. It also includes a propellant gas. As it dries, the coating develops a nanostructure through self-assembly. Fig. 3 at the left, shows water droplets on a wood surface treated with BASF's "Lotus Spray". Water does not enter into the open pores of the wood. The wood can't rot (Fig. 6) (Anous, 2014, p. 18).

Fig. 6. Water-Repellent Wood and the Self Cleaning Wood Project by HESB.

Fig. 7. Water-Repellent Wood and the Self Cleaning Wood Project by Blue Mosque, Tabriz.

Nano-coating for Ceramic, Porcelain, Granite and Marble

This type of Nano-Coating is used for glass & ceramic cooktops, hotels, restaurants and kitchen studios. It is perfect for counter tops, tiles and shower stalls. It repels liquids and dirt which makes it easier to clean and maintain. It is resistant to extreme weather conditions and temperatures and can be applied in several coats to ensure complete environmental protection. It provides complete protection against cracks and keeps the material looking shiny and new through time. It is Anti-Graffiti. It protects the material against stains, soap scum, calcium buildup and other chemicals. Once Nano-coating is applied, the surface is easily cleaned without detergent (Fig. 8) (Anous, 2014, p. 18).

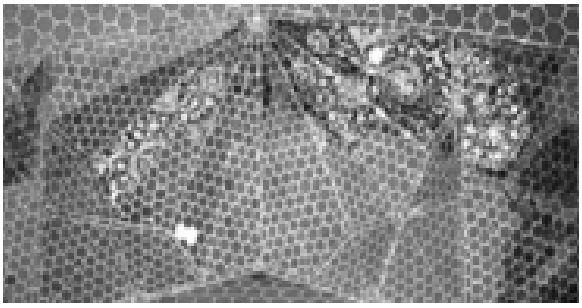


Fig. 8. Shows the Resistant to Extreme Weather Conditions and Temperatures by Blue Mosque, Tabriz

Nano-coating for Wall Covering

Nano-Coating for Wall Covering is developed as a reliable wall covering with a Nano-ceramic coating called *ccflex*? It is breathable while simultaneously water, flame, impact and chemical resistant. It is also lightweight. *ccflex* is currently manufactured by Marburg, who purchased marketing rights in 2009 (Anous, 2014, p. 20).

CONCLUSION

Preservation of the historical monuments with their inner values requires maintenance. Using modern technologies and achievements besides the past architecture experiences and arrangements is seeking a way to optimize energy in current constructions. In this regard, we need new methods that are not in contrary to repairing principles and ensure the monuments stability. Nano-technology is an effective approach in repairing and obtaining hydrophobic surfaces that try to improve building materials conditions by offering different products. This method has features of a proper insulator and, in addition, preserves the surface visual values and preserves durability and respiration. It is obvious that using these methods and materials is rational in terms of function and application, but it is necessary to adopt

with environment and materials and therefore, to propose propositions after field and laboratory tests. The use of nanotechnology, therefore, follows an ongoing demand for innovation because of its independence with marketing factors. Nanotechnology can also make contributions to buildings in the following areas:

- Optimization of existing rammed walls؛
- Damage protection in rammed walls؛
- Reduction in weight and/or volume؛
- Reduction in the number of production stages؛
- A more efficient use of materials؛
- Reduced need for maintenance (easy to clean, longer cleaning intervals) and/or operational up keep and as a direct result:
- Reduction in the consumption of raw materials and energy and reduced CO_2 emissions؛
- Conservation of resourcesGreater economy

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