Nano coating and reducing the energy consumption in city buildings
Prof. Dr. Farshad Nasrollahi, Dr. Ebrahim Moradi, Ma student. Maryam Rafiei
1- Berlin University of the Arts, Building Services Engineering (VPT)
Email: f.nasrollahi@udk-berlin.de
2- Art and Architecture Group, Architecture Department, Islamic Azad University, Science and Research Branch, Ilam, Iran
Email: moradi@ilam-iau.ac.ir
3- Art and Architecture Group, Architecture Department, Islamic Azad University, Science and Research Branch, Ilam, Iran
Email: arc_rafiee@yahoo.com
Adopted from master thesis.

Abstract
Using the smart materials in building industry improves the conditions for buildings’ users. Nano materials are smart materials that made advance changes in the optimization of building energy consumption by making nano coating that is discussed in the present paper. The aim of this study is to find the effects of nano coating in the optimization of building energy consumption in buildings. The method is library and Internet and sample survey. This research results is to achieve the features of nano coating in 90 % reduction of adverse effects of solar radiations, heat Resistant Waterproof Coating and reduction of energy waste in buildings.

Keywords: thermal nanocoating, wet nanocoating, the optimization of energy consumption

1. Introduction
Since Richard P. Feynman in 1959 stated his controversial ideas, the world began shrinking so that everything became small, light, compressed and very advanced. Nano technology will affect the countries’ economic future and their positions in the world. Due to the consequences and achievements of this technology, in the field of changing the building materials and construction technology, the study of nano building coating has been paid much attention in the present study. The optimization of energy consumption is one of the issues considered highly by countries for saving the energy consumption and reducing the financial costs. In Iran also this issue has been paid much attention in the past few years. Since coating can highly prevent the energy waste in buildings, the present study has been carried out to identify the nano coating and its effect on energy waste.

2. Nano coating
Nano coating can be discussed in three areas of acoustic, thermal, and wet therefore we introduce them and their manufacturing companies.

2.1. Aerogel and Nanogel thermal coating
Aerogel is a kind of super light foam composed of 95 to 99/9% air. Foam material is similar to a glass known as Silica (Silicon dioxide). The created holes in the Aerogel mass have a diameter less than 100 nano meters. Density of 30 kg/m3 is common for these materials. Developments in the field of Aerogels have led to the generation of a product as Nanogel. The dimensions of fine nano of the Nanogel’s holes have an important role in the foam. The air molecules are stuck in the fine nano holes (with the dimensions of 20 nano meters) and cannot move so they have the super capability of Aerogel. Nanogels that have a porosity of about 99% have the ability of light admittance and Semi-transparency and are useful for the buildings’ Semi-transparent coating and solar cells. The super thermal resistance of these coating can be achieved from their slight Heat transfer coefficient (0/018 w/mk).[1]

Figure 1. Bearing the brick piece weight by Aerogel.[2]

Nanogel reduces the sound transfer dramatically. Each centimeter of this material is much effective than the Argon glasses or wool walls.[3] By producing Aerogels with super porosity, significant features of nano materials can be used in improving the acoustic quality. Aerogels can play a role in thermal coating and acoustic coating and can also represent a kind of multi-functional coating in buildings. Kalwall Corporation located in Manchester, America is one of the manufacturers and distributors of Nanogel glasses known as Kalwall introduced as: Kalwall can be the entire or part of the wall of roof (as wall,
window, roof window, skylight ...). It is not plastic or glass but is much more valuable than what it seems. The main structure of Kalwall is a composed panel sandwich strengthened under the pressure and heat by fiberglass and is located at the aluminum atomic lattice structure with I-shaped beams. In fact, Kalwall has millions of glass yarns that reflect the direct sun light and radiates it inside the place. Its ability in reducing the heat or cold and controlling the solar heat in places significantly saves the cost of air conditioning and then creates a comfortable place in the building.

Figure 2. The structure of Kalwall coating.[4]

2.2. Thermal barrier materials

Nanocoatings and nano colors are the wet barriers that can be used as thermal coating. The new coating with a slight thickness of few thousandths of an inch is more effective than the common coating such as fiberglass and polyester without having the adverse effects of these materials.[5] Thermal barrier coating is mainly applied as the spray on the surfaces and this thin layer will play the role of a thermal coating. The basis of most of these coating is TiO2 and ZrO2. The main structure of other coating that is used less is composed of porous ceramic materials. These thermal barriers are mainly used in high temperature places. In most methods several layers of these materials are used and in spray methods, the melt or solid metal nano particles that were softened under heat are sprayed on the surfaces. In applications that the coating plasticity is more important than the resistance another method based on the nano composite polymers composed of ceramic nano materials are used. It can be said that adding the nano particles to the desired coating adds to its adhesion ability and its softness. Nanocoatings is softer and stronger than the traditional coating.[1] In general, thermal barriers materials can be considered as the wet and wet-thermal coating and their features are as follows:

2.2.1. Nano wet-thermal coating

These nanocoatings are used for the wet-thermal insulation of all industrial and building surfaces, retrofitting and anti-decaying the surfaces and then for increasing the structures’ lives. They prevent the wet (100%) and warmth and cold (more than 40%) and are considered as a complete insulation with a low thickness (a hundred micron), very high strength and adhesion. These nanocoatings can be applied to any surface such as: roofs and ceiling of coating, pools, facades, hospitals, refineries, facilities and industrial tanks, boilers and etc. The main part of these nanocoatings is Nano Silica Sol. This material creates units with a lot of lint and low density to restore the air in nanometric dimensions and prevent the wet influence and this material has also a very low thermal conductivity (0/017 w/m·k). Another part of these nanocoatings is Polymer resin that create anti-wet coating, heat, decay, corrosion with a high adhesion with the final goal of making a very resistant coating with low thickness to be a wet-thermal coating with anti corrosion and decay ability in different colors. They have the capabilities of high resistance to the growth of bacteria, mold and fungus, high resistance to UV beams, breath taking ability and the feature of coordination with the environment and human health. Also due to the past experiments, this coating can be used to prevent more than 40% of the energy waste in buildings.

2.2.2. Wet nanocoating

The features of wet nanocoating are: Water-based color, single-component, the lack of need of the solvent, and converting to the various colors, temperature resistance from -40 to +210 °C and preventing the influence of warmth and cold to the building, very high flexibility, very strong, anti-moisture coverage, waterproof, resistance to the influence of rain and environment wet, resistance to the UV beams, very high resistance to the different climates, the lack of the need of the destructing the existing surface layers, easy and quick running by brush, roller or spray. Other applications of these nanocoatings are sealing and insulation of the floor, roof, facades and toilets, applicable to the tar layers and old asphalts needless of the re-running the asphalt or tar layer, foundation isolation of buildings and surfaces in contact with soil, sealing and painting the pools, saunas, Jacuzzis, and parts in contact with wet, sealing and isolation of walls and facades and slope surfaces isolation and gable roof made of hot and steel galvanize.[6] Nano coating can be classified into two groups of color and transparent.

2.2.3. Color nanocoating

Color nanocoating is resistance to the influence of warmth and cold. In addition to their insulation feature that is three-dimensional (influence to the bottom of the surface) due to their nano structure. They are not like other common coating that are vulnerable to the different climates and UV beams and insulate the desired surface in molecular dimensions.[7]

2.2.3.1. Manufacturers of color nano coating
Nanofan Company: Nanofan industrial coating company was established in Iran in 1385. This company reduces the costs of energy consumption, thermal and wet insulation and reduces energy consumption in processing units and technical buildings. It is also the producer and distributor of nanocoating color in the Middle East. Nanocoating color is applied for the insulation of walls, tanks and etc. by simple methods of spray, roller and brush. Its included nano material is Nano Silica Sol XL100 that provides the ability of insulation, anti corrosion and thermal barrier. Nanocoating color is a combination of water based acrylic color with high quality and the introduced nano composite with a very low heat conductivity. If the nanocoating color is used in 3 layers with the thickness of about 200 microns on the wall, then the heat transfer coefficient will be 0.3635 w/m²k. The features of thermal nanocoating at this company include at least 40% in the energy consumption, water based color, needless of solvent, friend of environment, applicable to the facades, and the ability of adding the water based pigment to change to the various colors, applicable as the transparency, the ability of color breath and coverage, anti-UV beams.

![Figure 3. The energy waste rate from the building surfaces covered with the Nanofan nano coating.][8]

![Figure 4. Color chart of nano coating- Nanofan Company.][8]

The features of wet nanocoating include the wet-thermal insulation simultaneously in a product, anti-moisture coverage, waterproof, buildings foundation, surfaces in contact with soil, water based color, preventing the influence of heat and cold into the building, very high flexibility, convertible to the different colors, resistance to the UV beams, very high resistance to the different climates, needles of destructing the existing surface layers, applicable to the asphalt, metal surfaces and all concrete surfaces, stone, mosaic and competitive to the common wet coating such as tar layer and asphalt shingles.

![Figure 5. Painting the nanocoating with French curve.[8]]

![Figure 6. Painting the nanocoating with brush.[8]]

STO Company: STO Company is the manufacturer of paints and nanocoatings in New Zealand and Australia that is currently the manufacturer of its products in more than 50 countries (including Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Poland, Russia, Sweden, Switzerland, China, Malaysia, Singapore and the U.S). The external nanocoating are one of this company’s products that have the Self-cleaning silicone resin materials and retain the building façade against the climate changes. These resins waterproof the façade and remove the stream in the air and rain and also prevent the influence of Carbon dioxide into the façade. They provide a desired curve of the temperature and retain the heat inside the stony walls. StoLotusan Color G is one of this company’s products that will be introduced later.

StoLotusan Color G is a good coating for the façade and roof and is a self-cleaning color for facades. This coating has the features of Lotus effect, removing the façade’s pollution with rain drops, long life, resistance to the impact, weather and rainfall, the ability of ductility, resistance to the growth of micro-organisms, stable color, the breath taking ability of façade while is still the repellent of water, the water based color, contains Silicon resins and Titanium Dioxide, and usable for the façade of old and new buildings. Currently, the products of STO have the international standards of façade coating for stability more than 40 years.[9] However the self-cleaning colors containing the TiO₂ nano particles cannot be applied to the building colors that have organic structures. They are only usable for the surfaces with mineral materials since the TiO₂ nano particles attack the organic colors and break them up.[1]

Nanopush Company: Nanopush Company is another Iranian company that produces coatings. Its products
include the coating of NPS-320 surfaces that are the nano-based penetrating materials. This nanocoating with no changes in color and the appearance of surface penetrates into the applicable sections and removes the surface absorption to make them resistant to the influence of water, dust, and atmospheric gases. Its characteristics include 100% waterproof coating, full penetration into the structure depth, a kind of thermal-cold coating for the façade, self-cleaning feature of surfaces after the rain, applicable to the wet surfaces, with technical knowledge and primary materials of Fort nps Company in Germany according to the D.I.N and A.S.T.M standard. Its milky color is colorless after the application and has no Chloride ion.

2.2.3.2. Transparent nanocoatings

These coatings are in three general groups that are later discussed. Zycosil and Tenten nanocoating have been introduced as the transparent nanocoatings.

**Type 1- wet coating:** by applying this transparent coating to the roofs and façades of buildings, the desired surfaces can be insulated against the penetration of moisture and can be prevented the quality reduction of infrastructure materials overtime.

**Type 2- Anti-static coating:** by applying this transparent coating to the façades of new buildings, the desired surfaces can be insulated against the penetration of pollutants. Zycosil is one of the produced transparent nanocoatings that is considered as the wet nanocoatings and is somehow the thermal-cold coating for glasses.

**Zycosil** is a wet barrier of ZYDEX Company that managed to waterproof the buildings materials through the inspiration by technology in the nature (such as the coating of the leaf in water lily). These materials provide the waterproofing at a molecular level (even for inorganic materials). This new product has been formed based on the chemistry of organic silicon and therefore can adhere to the inorganic levels. Its solvent is water and per each cubic meter of using these materials, an efficiency of more than 80% to the similar old samples can be achieved. Zycosils contain nano particles with the dimension of 4 to 6 nanometer solved in water and penetrate deeply to the holes (3 to 5 mm).[1]

ASTM standard experiments have shown that the expected life for these dams is between 20 to 30 years. These materials are fined with the ratio of 1 to 10 through the piped water in the buildings and distribute a very small size of organic particles into the air. Zycosil is non-flammable and has a long life to the abrasion, water, harmful gases, and UV beams (at least 20 years under difficult conditions). Transparency without making any change in color, the ability of breath taking of the surfaces, self-cleaning and its non-toxicity are its features.

Zycosil cannot be used on Acrylic paints and cannot fill the large and deep cracks and should also be used after fining during 48 hours. Direct plastering, installing ceramic, stone and etc, cannot be done on the surface covered with Zycosil and should be covered with Zycoprime. The surface covered with Zycosil cannot be covered directly with the cement paints and should be used after applying the cement paints.

**Type 3- Thermal barrier coating of the distribution of ultraviolet and infrared radiation:** by applying this transparent fluid on the window’s glass can be prevented the entry of 99% of ultraviolet beams and 70% of infrared beams into the buildings and also 70% of the exit of the warmth outside of the building in cold seasons. (Thermal energy). By applying this coating on the glass of double-glazed windows, its efficiency can
be increased to 40%. The other features are anti-electromagnetism and anti-toxicity and also the environmental sustainability. [11,12] Security window films have a thickness of 100 to 300 micron. The heat transfer of this coating is similar to a 30 cm brick wall and the glass will be nano after 10 minutes with the environment temperature.

**Tenten nanocoating:** It is a tag that its nano particles pass the light with the high transparency and prevents the energy waste and infrared beams by insulating the glasses. Its durability is more than 15 years.

![Figure 11. The lack of throwing the glasses covered with the window film.][11]

**Nano coating G 1:** It is one of the Tenten Company’s products that have building consumption. This colorless thermal coating is transparent and anti-UV beams and is applicable to all glasses of buildings, vehicles, plains, trains and etc. The features of this nano coating is the prevention of heat transfer by glass to 90% , the prevention of UV beams more than 90% , the reduction of energy consumption from 35 to 42%, the prevention of energy waste in summer and winter and transparency more than 90% that can be kept to 10 years.

3. **Results**

Nano technology has been used in construction industry from producing the smart glasses to producing the anti-bacterial surfaces, self-cleaning surfaces, air-conditioning surfaces, self-repairing surfaced and etc. Given the above mentioned issues, it can be seen that the nanocoatings reduce 40% of heating and cooling energy in buildings. Transparent nanocoatings in glasses reduce the energy waste significantly and minimize the adverse effects of solar radiations. Removing the environmental pollution in hydrophilic surfaces of self-cleaning glasses, 80% reduction of energy waste and 99% removal of the UV beams are the features added to these glasses by nanocoatings. Making wet-thermal nanocoating is another achievement of nano technology that significantly reduces the costs of buildings’ insulation.

4. **Conclusions**

The problems with which we are faced are the increase of energy demand, mortality of fossil reserves and environmental problems due to the use of pollutants. Using the energy sustainable resources is one of the current solutions and using the current energy resources is another solution for the problems. Using the coatings made of nano technology can play an important role in optimizing the energy consumption. According to the present study, nanocoatings can insulate the buildings and reduce the heating and cooling energy to 40% and by using these coatings in glasses, 90% reduction of energy waste can be achieved. Nanocoatings are more effective than the common coatings despite their slight thickness (about 200 micron) and this is due to their very low Thermal conductivity coefficient. In the current buildings the walls cannot be insulated with common coatings but nanocoatings provide the ability of insulating buildings after several years of their constriction.

5. **References**


[8] www.nanolsola.com

[9] www.sto.co.nz

[10] www.nanope.com


