Volume 8, Issue 2, 2018, 3130 - 3133 ISSN 2069-5837
Biointerface Research in Applied Chemistry
www.BiointerfaceResearch.com
Original Research Article Open Access Journal
Received: 25.02.2018 / Revised: 07.04.2018 / Accepted: 13.04.2018 / Published on-line: 15.04.2018

Reduction in carbon dioxide emission with nano paint on building: a case study

Sara Farahmand [1], Bizhan Honarvar [2,*], Mansoor Taheri [3]
[1,2]Department of Chemical Engineering, Marvdasht Branch, Islamic Azad University, Marvdasht, Iran;
[2]McKetta Department of Chemical Engineering, University of Texas at Austin, 200 E. Dean Keeton St., Stop C0400, Austin, TX 78712-1589 United States;
[3]Department of Chemical Engineering, Shiraz University, Shiraz, Iran;
*corresponding author e-mail address: **honarvar2@gmail.com**

ABSTRACT
Reduction in carbon dioxide emission in the environment will be achieved if the amount of consumed fossil fuels is reduced. In this case study, the relation between the carbon dioxide emissions is considered with the required amount of heating load in one residential building. The effect of applying nano paint on exterior walls of a building on the reduction of the carbon dioxide emission is paid attention as a novel view point to the nano paint. This is illustrated that façade coverage of the residential building complex with nano paint can be introduced as a novel, promising, cost-effective technique to reduce residential CO_2 emission about 57.97 ton/year.
Keywords: *Nano paint; CO2 emission; building façade; historical data***.**

1. INTRODUCTION

CO_2 emissions have been announced as one of the environmental issues for more than ten years[1- 10].. As we know, hydrocarbon combustion releases CO_2 emissions On the other hand, fossil fuels have been the main on demand stocks of providing energy for the past years and will be for many years in the future [10], [11]. Natural gas is widely consumed in commercial, industrial, residential and transportation sectors [10], [11].

According to the EIA reports, the main sources of CO_2 emissions have been transportation, industrial, residential and commercial sectors, respectively from 2010 to 2016 [12]. This is predicted that CO_2 emissions from natural gas will be 1513 MMT in 2018 [12], [13]. The natural gas CO_2 emissions were after electricity CO_2 emissions during 2000 to 2016 in U.S. US carbon dioxide emissions related to the residential was averagely 300 MMT at the first quarter during 2010 to 2016 [12], [13].

Residential space heating is provided by natural gas combustion during winter. This increases the demand for natural gas import, predominately in Iran during these times [14], [15]. In Iran, residential sector holds 40% of CO_2 emissions which were reported 510, 560, 570, 590 and 605 MMT in 2008, 2009, 2010, 2011 and 2012, respectively [12-13]. As the best of our knowledge, survey about the reduction of residential CO_2 emissions is directly concerned with the environmental engineering and air pollution management .

1.1 Multi-functional paint.

Paint has been applied to make a good appearance for the material besides of protection against corrosion and erosion, for many years. Nowadays, paint industries focus on new paints with multifunctional characteristics such as anti-fungi, anti-bacterial, insulation, fire resisted and water resisted while improving the main properties of paints [16], [17], [18]. These achievements have been investigated by addition of nanostructures in the paint which have shown acceptable results. Nanostructures in the paint make a nanoporous media after drying which traps air inside it and prevents heat conduction and convection while it making a softer and more uniform coverage on the surface than the paint without nanostructures.

In this study, the effect of nano paint on the exterior walls, façade, of a residential building is investigated on the reduction of CO_2 emission for the first time. Also, the historical data of the consumed gas was provided for eight years.

2. MATERIAL AND METHOD

The case study is a residential building complex with 100 apartments which is located in (29̊ 32́ N and 52̊ 36́ E), Shiraz city, Iran. The building was constructed on 2006 and there were not applied any insulation in the structure of the building. The building exterior walls were mainly made of cement blocks and were painted by acrylic paint containing nano structures on 2014. Some characteristics of the applied paint are shown in Table 1.

The central heating system is based on hot water circulation provided by natural gas combustion in a boiler. Electricity was not used for heating in this building complex. The direct relation between declining in the amount of ambient temperature and the amount of gas consumption is obvious. According to the Shiraz climatic conditions, the maximum amount of required heating is reported on January, February and March when the ambient temperature is at the lowest amount among the other seasons [14],

[15]. So, in this study, the first quarter of the year is considered to evaluate the effect of nano painted façade on the amount of gas consumption in the residential building.

Figure 1 shows the temperature gradient in the building wall which is composed of dense plaster, gypsum board, concrete block respectively from inside to the outside of the building. Although in the temperature profile, the resistance of inside air film and outside air film is presented. The comfort temperature inside the building is assumed 25 °C and the lowest and highest amount of outside temperature is -2 °C and 37 °C in winter and summer, respectively. OPAQUE 3.0 BETA is applied to resume the wall of building considering the weather data file of Shiraz.

To do this, based on the historical data from the reported gas bills of Shiraz gas company the analysis was done. The volume of consumed gas has been considered during the first quarter for years before painting and years after that. The CO_2 emissions related to the gas combustion is calculated. The emissions are compared before coverage of building façade and after that, and then the results are assessed.

2.1 CO2 emission calculation.

According to the definitions of CO_2 emission in IPCC 2006 guidelines there are three tiers to calculate this amount [19]. Tier 1 is used in this study to obtain the allocation of residential space heating in the case study. In this method, the combustion conditions are not important and assume that the complete combustion is done. Equation 1 and 2 shows the relation between the consumed natural gas which is mainly for space heating and CO_2 emissions (CE) [19].

$$CE=FC\times NCV\times CEF \quad (1)$$

$$CEF=CC\times COF\times M\_CO2/M\_C=56100 \quad (2)$$

Where:

CE: CO_2 emission, kg

CEF: CO_2 emission factor, kg/Tj

FC: The amount of consumed gas, kg

NCV: Net calorific value of gas, Tj/kg

CC: Carbon amount in the gas

COF: Carbon oxidation factor =1

Table 1. Paint characteristics

Water-based Acrylic Insulation Coating				
Appearance	Thermal conductivity W/m.℃	pH	Permeability (perms)	Volatile organic compounds (VOCs) kg/ m3
Liquid White	0.075	6-8	0.0138 at 23 ℃	142

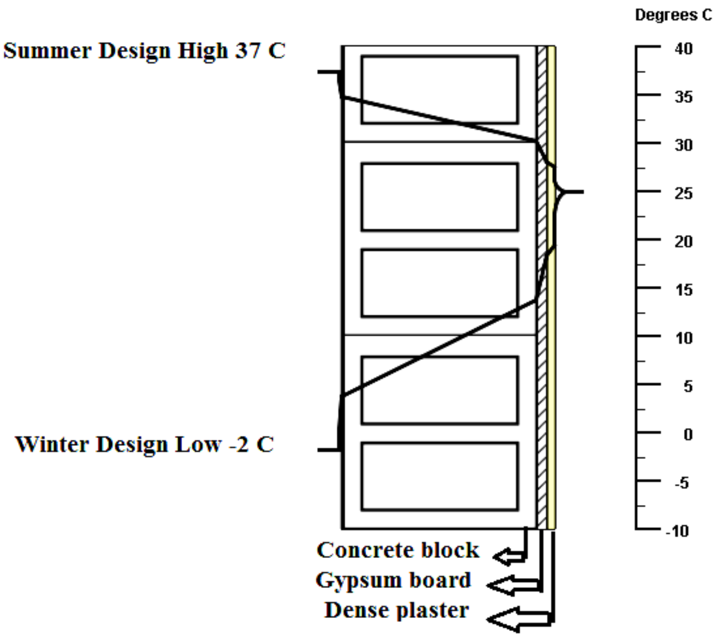

Figure 1. Temperature profile in building wall section which is simulated by OPAQUE 3.0.

3. RESULTS AND DISCUSSION

Historical data of consumed gas volume by the residences of the building complex are shown in Figure 2. Six years before the painting and two years after that from 2008 to 2016. The data for consumed gas on 2014 doesn't be considered because exterior walls were painted on 2014.

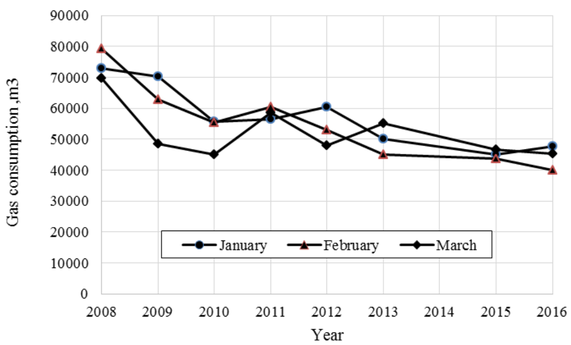

Figure 2. The amount of gas consumption during the first quarter.

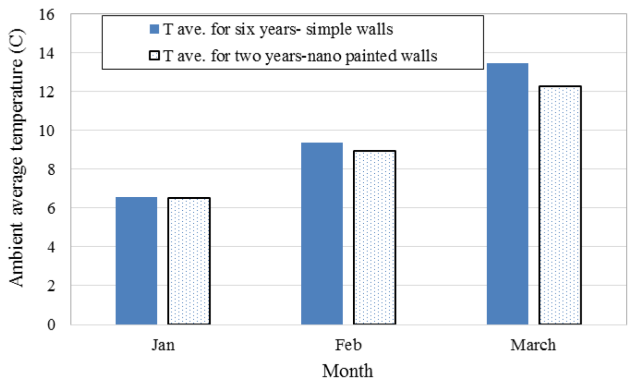

Figure 3. Average temperature of the ambient.

According to the data, the irregular changes with fluctuation can be seen on each month. Also, the lower amounts of gas consumption are obtained on 2015 and 2016 compared with those are obtained on 2008 to 2013. So, this is questionable if the lower amounts of consumed gas in 2015 and 2016 are achievable normally or these are since of the nano coverage of façade. The amount of required gas for space heating is dependent on the ambient temperature difference with inside temperature, 25 °C, directly.

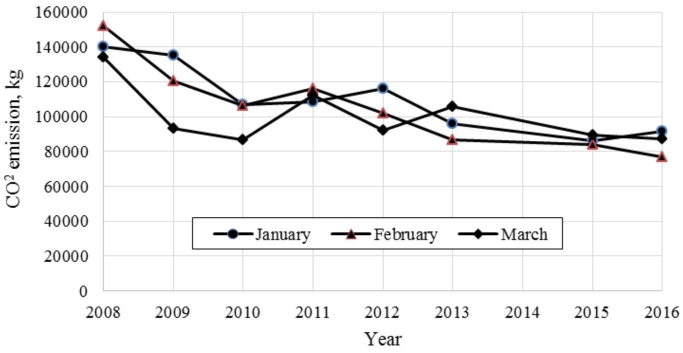

Figure 4. Residential CO_2 emissions for the case study.

The average ambient temperature (AAT) of Shiraz according to the Fars Bureau of Meteorology are found during 2008 to 2013 and also the average temperature during 2015 and 2016. Figure 3 shows the recorded values. According to Figure 3, the AAT for 2015 and 2016 is about 5% and 9% lower than that is for 2008 to 2013 on February and March, respectively.

The AAT on January is approximately the same before painting, 6.58 °C, and after that, 6.5 °C. Due to the temperature data, after the painting , the higher amount of gas is required for heating of the inside building to reach 25 °C for the first quarter. However, the historical data shows the reverse conclusion and the lower amount of consumed gas is reported after the painting of the building façade. This can prove the positive role of nano paint on the reduction of the consumed gas for heating.

Figure 4 shows the amount of carbon dioxide emissions from the residential sector of the studied building. Obviously, the lower amount of burning gas for space heating the lower carbon dioxide emission is expected. According to the results, the average of CO_2 emissions during the considered investigation (2008 to 2016) are 109969.4, 10549.8 and 99971.28 on January, February and March, respectively.

For better analysis these amounts are set as the criteria and the CO_2 emissions after painting with nano paint are compared with them for the first quarter. Standard deviation of CO_2 emission (SDCOE) from the average values are calculated according to Equation 3 and Figure 5 shows the results.

SDCOE = (value of COE -average of COE)/ average of COE

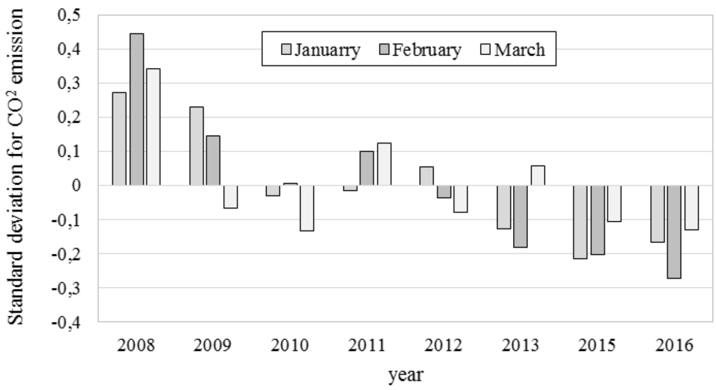

Figure 5. SDCOE for the case study.

For three months in the first quarter, the standard deviation from the average of CO_2 emission during 2008 to 2016 is presented in Figure 5. The positive data from zero value shows that the CO_2 emission is higher than average on that month and the negative data shows the lower CO_2 emission than the average amount of that on the related month.

Figure 5 indicates on the residential CO_2 emission reduction of about 22%, 20% and 10% on 2015 and 17%, 27% and 13% on 2016 for January, February and March, respectively. This is illustrated on the positive effect of nano paint on the reduction of CO_2 emission.

4. CONCLUSION

Many people wonder a useful and feasible cost-effective technique to protect their environment. The purpose of this investigation is to present a new viewpoint of application of nanotechnology and paint industry on environmental protection. For this, one residential building is considered which nano paint was applied on the facade. The historical data of the consumed gas for the years before painting and after painting are compared, at the first quarter. The CO_2 emissions related to the consumed gas for heating are calculated and compared. Finally, the results show the reduction in the amount of consumed gas and in the CO_2 emission after painting of façade with nano paint.

Nano paint with the low thermal conductivity can be as an insulator; however, the paint thickness is not comparable with that for other commercial insulators. Moisture evaporation from facade cools the exterior surface of the building and increases the fuel demand for space heating after raining. Nano paint coverage also making uniform texture on the surface and prevents moisture penetration on the façade. So, it prevents temperature reduction of the building exterior surface. These can be two main reasons which help in CO_2 reduction after coverage of façade with nano paint.

Other than the role of nano paint in the reduction of CO_2 emission at the heating days, the authors are interested in the role of nano paint in energy saving of the building after nano painting the façade. Also, the effect of nano paint will be considered on the CO_2 emission on cooling days.

Finally, the results show that applying nano paint on the facade can be a feasible choice for the residential and also commercial building to reduce the CO_2 emission while providing suitable cost effective façade for the buildings of the towns.

5. REFERENCES

[1] Modak N. M., Ghosh D. K., Panda, Sh., Sana, Sh., Managing green house gas emission cost and pricing policies in a two-echelon supply chain, *CIRP Journal of Manufacturing Science and Technology*, 20, 1-11, **2018.**

[2] Geng P., Tan Q., Zhang Ch., Wei L., He X., Cao E., Jiang K. Experimental investigation on NOx and green house gas emissions from a marine auxiliary diesel engine using ultralow sulfur light fuel, Science of *The Total Environment*, 572, 467-475, **2016.**

[3] Adam A.D., Apaydin G., Grid connected solar photovoltaic system as a tool for green house gas emission reduction in Turkey, *Renewable and Sustainable Energy Reviews*, 53, 1086-1091, **2016.**

[4] Menke R., Kadehjian K., Abraham E., Stoianov I., Investigating trade-offs between the operating cost and green house gas emissions from water distribution systems, *Sustainable Energy Technologies and Assessments*, 21, 13-22, **2017.**

[5] Colling A.V., Oliveira L.B., Reis M.M., da Cruz N.T., Hunt J.D., Brazilian recycling potential: Energy consumption and Green House Gases reduction, *Renewable and Sustainable Energy Reviews*, 59, 544-549, **2016.**

[6] Vlontzos G., Pardalos P.M., Assess and prognosticate green house gas emissions from agricultural production of EU countries, by implementing, DEA Window analysis and artificial neural networks, *Renewable and Sustainable Energy Reviews*, 76, 155-162, **2017.**

[7] Grigoratos Th., Fontaras G., Martini G., Peletto C., A study of regulated and green house gas emissions from a prototype heavy-duty compressed natural gas engine under transient and real life conditions, *Energy*, 103, 340-355, **2016**.

[8] Lazzerini G., Lucchetti S., Nicese F.P., Green House Gases(GHG) emissions from the ornamental plant nursery industry: a Life Cycle Assessment(LCA) approach in a nursery district in central Italy, *Journal of Cleaner Production*, 112, 4022-4030, **2016**.

[9] Forte A., Fagnano M., Fierro A., Potential role of compost and green manure amendment to mitigate soil GHGs emissions in Mediterranean drip irrigated maize production systems, *Journal of Environmental Management*, 192, 68-78, **2017**.

[10] Greiner P.T., York R., McGee J.A., Snakes in The Greenhouse: Does increased natural gas use reduce carbon dioxide emissions from coal consumption?, *Energy Research & Social Science*, 38, 53-57, **2018.**

[11] Qin Y., Tong F., Yang G., Mauzerall Denise L., Challenges of using natural gas as a carbon mitigation option in China, *Energy Policy*, 117, 457-462, **2018.**

[12] Annual Energy Outlook 2015 of Energy Information Administration. Retrieved on 16. 3. 2016, from http://www.eia.gov.forecasts/aeo/

[13] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. Retrieved on 8. 3. 2016, from http://www.eia.gov/statistics/

[14] Clyde & Co., Iran's new Integrated Petroleum Contracts, Retrieved on 11. 5. 2014, p. 3.

[15] Middle East Economic Survey, Iran Beats the Odds with 20% Gas Output Hike, Retrieved on 13. 3. 2015, 58, 11.

[16] MacMullen J., Zhang Z., Radulovic J., Herodotou C., Totomis M., Nath Dhakal H., Bennett N., Titanium dioxide and zinc oxide nano-particulate enhanced oil-in-water (O/W) facade emulsions for improved masonry thermal insulation and protection, *Energy and Buildings*, 52, 86-92, **2012.**

[17] Dashtizadeh A., Abdouss M., Mahdavi H., Khorassani M., Hosseini J., Modification and improvement of acrylic emulsion paints by reducing organic raw materials and using silica nano composite, *Journal of Polymer Engineering*, 33, 357-367, **2013.**

[18] Wagner A., Bajsić I., Fajdiga, M., Measurement of the surface-temperature field in a fog lamp using resistance-based temperature detectors, *Strojniški vestnik – Journal of Mechanical Engineering*, 50, 2, 72-79, **2004.**

[19] IPCC., Emission factors for greenhouse gas inventories, Intergovernmental panel on climate change, **2013**.