



Plasma Technology for Air Pollution Control: A Policy Brief

Niloofer Damyar ^{1,2}, Ali Khavanin ^{2*}, Ahmad Jonidi Jafari ³, Hassan Asilian ², Ramazan Mirzaei ⁴

¹ Department of Occupational Health Engineering and Safety, Damghan School of Health, Semnan University of Medical Sciences, Semnan, Iran.

² Department of Occupational Health, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

³ Department of Environmental Health Engineering, School of Public Health, Iran University of Medical Sciences, Tehran, Iran.

⁴ Department of Occupational Health and Safety Engineering, Social Determinant of Health Research Center, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran.

* **Corresponding author:** Ali Khavanin. Tehran, Jalal AleAhmad, Nasr. P.O.Box: 14115-111. **Email:** Khavanin@modares.ac.ir

Abstract

Objectives: The SO₂ emission from fossil fuel combustion in both industries and diesel vehicles is high due to their high sulfur content. This high amount of SO₂ emission into the environment leads to numerous economic and environmental consequences, including air pollution, an increase in the number of unhealthy days, and health impacts. This study aims to evaluate the efficiency of non-thermal plasma (NTP) technology in SO₂ removal from air.

Methods: In this study, the removal efficiency and energy yield of NTP technology were evaluated in SO₂ removal from air on a laboratory scale.

Results: The study found that the removal efficiency of SO₂ from the air using packed-bed NTP was over 90%, proving the effectiveness of this NTP technology. Additionally, the experiment revealed that this technology is highly energy efficient.

Conclusion: Based on the results, it is recommended that NTP technology, which does not require specialized or costly equipment, be utilized in source exhausts to decrease SO₂ emissions.

Keywords: Health Policy, Sulfur Dioxide, Air Pollution, Vehicle Emissions, Fossil Fuel.

Introduction

Sulfur dioxide is a significant air pollutant that is released into the atmosphere through the combustion of fossil fuels with high sulfur content^[1]. This pollutant has a wide range of negative health effects, including respiratory discomfort, mucosal irritation, genetic abnormalities, and even death^[2-5]. It is also a precursor of acid rain and has a global impact on air pollution, causing environmental damage^[6]. The economic impact of SO₂ should not be overlooked, as it imposes significant costs on societies, both directly and indirectly. Numerous studies have been conducted on the economic costs of air pollution, specifically focusing on SO₂^[7]. In developing countries, the sulfur content of gasoline and diesel fuels is often much higher than the recommended amount by the EPA (15 ppm)^[8, 9, 10]. When these fuels are combusted, almost all of the sulfur is converted to sulfur dioxide, resulting in exposure levels above the permissible limit (2 ppm)^[11, 12]. As a result, we see a rise

in both the number of unhealthy days experienced and the economic burden caused by air pollution. Therefore, controlling SO₂ is a serious challenge, particularly in developing countries where diesel fuels have a high sulfur content (1-5%)^[1].

Currently, there are two main gaps in SO₂ emission control: the lack of effective desulfurization technology for reducing the sulfur content of fossil fuels, and the lack of affordable technology for controlling the pollutant after it has been emitted into the air. There are two types of strategies for controlling SO₂ emissions: pre-emission and post-emission. The process of fuel desulfurization is a preventative measure for controlling the emission of SO₂ into the air, while NTP technology serves as a post-emission control measure for removing SO₂ from the environment. Various technologies, including catalyst conversion, scrubbing, and NTP technology, have been studied for their effectiveness in removing SO₂ from the air, either individually or in combination. NTP technology is widely considered to be the most effective

method for controlling air pollutants due to its ability to initiate the destruction process at ambient temperature, its energy efficiency, scalability, and applicability on an industrial scale. The purpose of this research is to investigate the energy and removal efficiency of NTP technology using a DBD reactor packed with ceramic granules, a type of dielectric granule, for the removal of SO₂ from the air.

Methods

To investigate the efficiency of NTP technology for removing SO₂ from real emission sources, the SO₂ concentration was examined in various exhausts from stationary and mobile sources. At the laboratory scale, SO₂ gas streams were diluted with air in different concentrations. Additionally, the NTP reactor filled with ceramic granules was selected for the experiments because ceramic granules are inexpensive and readily available due to mass domestic production. The process of investigating SO₂ removal from the air using NTP technology was conducted in the laboratory.

Results (Policy Options and Recommendation)

The use of NTP technology to control air pollutants aligns with the Islamic Republic of Iran's 5-Year Development Plan. This plan includes implementing policies to control air pollution, and according to this plan, the environmental protection organization must take measures to reduce air pollution to meet the standards set by the World Health Organization. Given the significant health, economic, and environmental consequences of air pollution, it is more crucial than ever to implement effective control solutions to manage the emission levels of pollutants from various sources. One crucial pollutant that requires control is SO₂, which is emitted at a high rate from fossil fuels used in industrial and diesel vehicle exhausts. This can be achieved by either reducing the amount of SO₂ in the fuel before combustion or by controlling its emission into the environment after combustion.

While refineries use various desulfurization processes to reduce the sulfur content of the fuel, the sulfur content remains high (1-5%), resulting in large amounts of this pollutant being emitted during combustion^[1]. Therefore, in this study, controlling SO₂ emission after the fuel combustion was considered, and the high efficiency obtained for removing this pollutant from the gas stream (94%) as well as its high energy efficiency showed that the application of this technology at the exhaust of emission sources, just before the emission of this pollutant into the environment, can prevent the emission of this pollutant into the air, in a large amount.

To effectively control air pollution and mitigate its consequences, industry owners must be knowledgeable about the latest and most efficient technologies for

reducing pollutant emissions and managing them once they are released into the air. This includes prioritizing energy-efficient technologies.

Additionally, governments, policymakers, and decision-makers should mandate the use of new and cost-effective technologies to decrease air pollution. We must acknowledge that air pollution has detrimental effects not only on the owners of companies that contribute to it but also on individuals who are equally affected by it. Therefore, non-governmental organizations should also be informed about and advocate for the implementation of the most up-to-date technologies for controlling air pollution.

Based on the findings of this study, it is recommended to utilize NTP technology, specifically a packed-bed system with inexpensive and easily accessible ceramic granules, at emission sources such as power plants and heavy vehicles. This technology is highly effective in removing large quantities of air pollutants, without requiring specialized or costly equipment.

Discussion and Implementation Considerations

The high emission of SO₂ from the combustion of fossil fuels has major health, economic, and environmental consequences. This pollutant is also a precursor to acid rain, which has raised concerns among researchers, policymakers, and decision-makers. The goal of this study, and others like it, is to find an effective solution for reducing the emission of SO₂ into the environment. One potential solution is to reduce the sulfur content in fuel, which has been largely successful with existing technologies. However, the sulfur content in fuel is still high, leading to high levels of SO₂ emissions^[1].

Therefore, extensive research has been conducted, including the present study, to find a solution for controlling SO₂ gas at the source of emission before it enters the environment. The results of this study show that NTP technology can achieve high removal efficiency and energy efficiency in removing this pollutant. This technology can be suggested to decision-makers as a control solution for the exhaust of emission sources. It does not require special equipment or expertise and can be applied to diesel vehicles and power plants. Therefore, it is recommended that NTP technology be applied to various emission sources' exhausts and that its effectiveness be investigated in real-world conditions.

Conclusion

From the results of this study, which indicate the high removal efficiency of SO₂ gas from the gas stream using NTP technology, as well as the high energy efficiency of this system, it is concluded that the use of NTP technology, which is simple to construct, commission, and does not require special equipment or expertise, is

very effective for controlling the emission of various pollutants, including SO₂, from stationary and mobile sources. The implementation of this control solution leads to a reduction in pollutant emissions, a decrease in the production of acid rain, which is one of the global consequences of air pollution, and a reduction in the health, economic, and environmental impacts associated with air pollution. It is hoped that by implementing the results of air pollutant control studies in real conditions, we will see an even greater reduction in pollutant emissions into the atmosphere, a decrease in related consequences, and an improvement in the quality of life and the environment in the future.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

NTP: Non-Thermal Plasma.

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Availability of data and materials

The data utilized in this study are available from the corresponding author upon request.

Ethics approval and consent to participate

The study received ethics approval for its implementation from the Ethics Committee of Tarbiat Modares University, with the ethics code IR.TMU.REC.1396.621.

Consent for publication

By submitting this document, the authors confirm their consent for the final accepted version of the manuscript to be considered for publication.

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