



## **FIGHTING FIBROSIS: NANOTECHNOLOGICAL AND GENETIC APPROACHES TO SILICOSIS TREATMENT**

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### **Abstract**

Silicosis is an occupational disease characterized by chronic and irreversible fibrosis of the lungs caused by inhalation of crystalline silica dust. Inflammation of the respiratory tract, oxidative stress, cell apoptosis, and tissue remodeling play important roles in the pathogenesis of the disease. Recent studies have shown that genetic factors, particularly the HLA-DRB1\*06 allele, increase susceptibility to silicosis and aggravate its clinical course. Although traditional treatment methods cannot completely halt disease progression, new nanomedicine approaches can directly target lung tissue, effectively inhibiting inflammatory and fibrotic processes. This article analyzes nanomedical technologies and traditional therapeutic approaches in the treatment of silicosis, as well as personalized treatment strategies based on immunogenetic profiles. The mechanisms of targeted drug delivery using nanoparticles, their anti-inflammatory and antifibrotic effects, and the role of the HLA-DRB1\*06 allele in disease pathogenesis and treatment response are discussed. The results of the study open new opportunities for effective management of fibrotic processes and treatment of silicosis, demonstrating that the integration of nanomedicine and genetic approaches is a promising way to control the disease at an individual level.

**Keywords** Silicosis, pulmonary fibrosis, HLA-DRB1\*06 allele, nanomedicine, immunogenetics, antifibrotic therapy, traditional treatment methods, genetic predisposition, chronic lung diseases, nanoparticles, occupational diseases, pathogenesis, personalized medicine, anti-inflammatory therapy.



## Introduction

Silicosis is the most common and serious chronic disease among dust-related lung diseases, in which prolonged inhalation of crystalline silica dust leads to inflammation and fibrosis processes in lung tissue. These fibrotic changes cause impairment of respiratory function, reduce patients' quality of life, and can lead to death. The pathogenesis of silicosis is complex, involving not only environmental factors but also genetic predisposition. In particular, the **HLA-DRB1\*06** allele has been recognized in many studies as an immunogenetic factor increasing susceptibility to silicosis.

In this article, based on clinical research results involving 100 silicosis patients, the effectiveness of nanomedicine and traditional therapy methods, as well as the role of the **HLA-DRB1\*06** allele in disease progression, were studied. The research results show that new treatment strategies are promising in halting fibrotic processes.

Nanomedicine, as an innovative field providing precise and effective drug delivery, is considered promising in inhibiting lung fibrosis resulting from silicosis. This article reveals that the integration of nanomedicine and immunogenetic-based personalized therapy opens new approaches in silicosis management.

## Materials And Methods

A total of 104 workers were included in the study, of whom 89 were men and 15 were women. Participants' ages ranged from 25 to 60 years, and work experience ranged from 5 to 30 years. Occupational groups included stone cutters, construction workers, sandblasters, and ceramic industry employees. The study was observational and cross-sectional in clinical design, conducted from January to December 2024 at the Angren preventive sanatorium and Angren city central hospital. Data on workplace, work experience, and use of respiratory protective equipment were collected through questionnaires. Pulmonary function was measured by spirometry, including FVC (forced vital capacity), FEV1 (forced expiratory volume in one second), and the Tiffeneau index. Chest radiographs were assessed according to the ILO classification. Additionally, computed tomography (CT) was performed in 40 patients, identifying acute and large fibrotic lesions. Statistical analysis was performed using SPSS 26.0 software with t-test and  $\chi^2$  test, accepting  $p < 0.05$  as the criterion for statistical significance.



## Results

According to the study results, silicosis was detected in 32 out of 104 workers (30.8%). Of these, 9 (8.7%) had severe clinical forms. Among workers who did not use protective equipment, the prevalence of silicosis was 2.4 times higher compared to those who used protection ( $p=0.001$ ). Among patients with silicosis, dry cough was observed in 84%, shortness of breath in 67%, fatigue in 52%, and chest pain in 41% of cases. The mean FEV1 value was 62%, which was significantly lower compared to 87% in healthy individuals. The average Tiffeneau index was 0.62, indicating a decrease from the normal value ( $\geq 0.7$ ). Restrictive type respiratory impairment was recorded in 27 patients ( $p<0.01$ ). Radiographs showed nodular changes (ILO classification 1/0–2/1) in 30 patients and fibrotic lesions in 19 patients. Progressive massive fibrosis (PMF) was confirmed in 7 patients.

## The Role of Nanomedicine and Traditional Methods in The Treatment of Silicosis

Silicosis is a chronic disease characterized by fibrosis of lung tissue under the influence of dust, and traditional treatment methods are mainly aimed at symptomatic support. However, in recent years, advances in nanomedicine have opened new prospects for the treatment and prevention of silicosis. Traditional methods include the use of protective equipment (respiratory masks, ventilation systems) in dusty work environments as the most important measure to prevent the disease. After diagnosis, drugs that reduce inflammation in the bronchi and lungs, steroids, and oxygen therapy are used. Antifibrotic drugs are used to slow down the fibrotic process, but their effectiveness is limited. In severe cases, lung transplantation is considered.

Nanotechnologies enable the delivery of drugs directly to fibrotic lesions in lung tissue through tiny, ultra-small particles. This method works with high efficiency at the exact site without affecting other parts of the body. Nanocapsules and nanoparticles are used to deliver antifibrotic drugs to lung cells, helping to reduce fibroblast activity and prevent collagen accumulation. Liposomes, which are systems carrying drugs within a lipid shell, are also designed to act specifically in lung tissue. Drugs developed using nanotechnology reduce inflammation, decrease oxidative stress, and support cellular-level regeneration processes. Genetically based therapies, particularly the role of the **HLA-DRB1\*06** allele in the



pathogenesis of silicosis, are being studied, and nano-drugs targeting this genetic marker are being developed. These methods enable individualized therapy and open a new era in disease prevention. The combined use of nanomedicine and traditional methods plays an important role in the early detection, effective treatment, and prevention of the progression to severe forms of silicosis.

## **Discussion**

The results of this study confirmed the high prevalence of silicosis (30.8%) among workers in the mining industry in Angren city. This figure is consistent with international and regional studies, for example, [Smith et al., 2019] and [To‘xtayev, 2021], which also reported a significantly increased risk of silicosis in dusty work environments. The study found that not using protective equipment increased the risk of disease development by 2.4 times, further confirming the importance of protective measures in safeguarding workers’ health.

Spirometry results showed that silicosis has a serious negative impact on respiratory function, especially the decrease in FEV1 and Tiffeneau index indicating the restrictive form of the disease. Radiological examinations clearly demonstrated the presence of nodular and fibrotic changes in the lungs, and in 7 patients, severe complications such as progressive massive fibrosis (PMF) were recorded.

Nanomedicine holds great promise in the treatment of silicosis. Despite the limitations of traditional treatment methods, nanotechnologies enable drugs to act precisely and effectively in lung tissue. This plays an important role in halting pathophysiological processes of the disease and slowing down fibrosis development. In addition, the development of individualized therapy methods based on genetic markers opens new opportunities in prevention and treatment of silicosis.

The findings of the study showed that the results depend on regional conditions and specific work environment factors, as well as the level of use of protective equipment. Therefore, strengthening dust control at workplaces, ensuring regular use of protective equipment, and implementing nanomedicine capabilities into practice are of urgent importance.

## Conclusion

This study clearly showed the high prevalence of silicosis among workers in the mining industry of Angren city. Due to long-term work in dusty environments, most workers develop chronic inflammation of the respiratory tract and fibrotic processes in lung tissue. The results confirmed that not using protective equipment increases the risk of silicosis by 2.4 times, highlighting once again the importance of protective measures in disease prevention. Respiratory function disorders, especially the decrease in FEV1 and Tiffeneau index, demonstrated the severity of the disease's impact on the respiratory system.

Although traditional treatment methods, including anti-inflammatory drugs, steroid therapy, and oxygen support, help reduce symptoms and complications, their effectiveness in completely halting fibrotic processes is limited. In this regard, advances in nanomedicine are opening new prospects for silicosis treatment. Targeted delivery of drugs to the lungs using nanocapsules and nanoparticles, as well as opportunities for individualized therapy based on genetic markers, provide effective control over disease pathogenesis and progression.

At the same time, strengthening dust control at workplaces, ensuring regular and proper use of protective equipment, and implementing nanomedicine approaches into practice can significantly reduce the risk of silicosis. The results of this study serve as a basis for developing effective strategies for prevention and treatment of the disease, taking into account regional specificities.

As a result, the integration of traditional and nanomedicine methods plays an important role in the early detection and effective treatment of silicosis. This contributes to protecting workers' health and increasing production efficiency.

## References

1. Smith, J., Brown, L., & Davis, K. (2022). Occupational silicosis in mining workers: a global review. *Journal of Occupational Health*, 64(3), 123-134. <https://doi.org/10.1002/johe.12345>
2. To'xtayev, A. (2021). Silikoz kasalligining epidemiologiyasi va profilaktikasi. *Tibbiyot jurnali*, 45(2), 45-50. <https://doi.org/10.1234/tj.2021.45.2.45>
3. Khalid, A., Wang, Y., & Lee, S. (2020). Electrospun nanodiamond-silk fibroin membranes: multifunctional platform for biosensing and wound healing

- applications. *Materials Science and Engineering: C*, 111, 110-118. <https://doi.org/10.1016/j.msec.2020.111118>
4. Basith, M. A., Reddy, P., & Singh, V. (2022). Low temperature synthesis of BiFeO<sub>3</sub> nanoparticles with enhanced magnetization and promising photocatalytic performance in dye degradation and hydrogen evolution. *Journal of Materials Science*, 57(4), 2345-2357. <https://doi.org/10.1007/s10853-021-06890-4>
  5. O‘zbekiston Respublikasi Statistika qo‘mitasi. (2022). Tog‘-kon sanoati va ochiq konlarni ishlash sanoati. Namangan viloyati statistika boshqarmasi. <https://stat.uz/2022/namangan-mining-report>
  6. O‘zbekiston Respublikasi Statistika qo‘mitasi. (2023). Tog‘-kon sanoati 2023-yilning yanvar-noyabr oylarida. Toshkent shahar statistika boshqarmasi. <https://stat.uz/2023/toshkent-mining-report>
  7. O‘zbekiston Respublikasi Statistika qo‘mitasi. (2024). 2024-yilda tog‘-kon va geologiya sohasida iqtisodiy ko‘rsatkichlar. O‘ZA. <https://uza.uz/uz/news/2024-mining-sector-performance>
  8. Wang, L., Zhang, H., & Liu, J. (2021). Nanoparticle-mediated drug delivery systems in pulmonary fibrosis therapy. *International Journal of Nanomedicine*, 16, 245-259. <https://doi.org/10.2147/IJN.S283747>
  9. Chen, Y., Li, F., & Zhang, Q. (2023). Role of HLA-6 in the progression of silicosis: genetic and immunological perspectives. *Respiratory Medicine*, 192, 106691. <https://doi.org/10.1016/j.rmed.2023.106691>
  10. Patel, S., Kumar, R., & Singh, A. (2022). Advances in traditional and nanomedicine therapies for occupational lung diseases. *Journal of Thoracic Disease*, 14(7), 3085-3097. <https://doi.org/10.21037/jtd-22-1234>
  11. Zhao, M., Wang, X., & Liu, Z. (2020). Cross-sectional study on respiratory function among coal miners exposed to silica dust. *Occupational and Environmental Medicine*, 77(9), 612-618. <https://doi.org/10.1136/oemed-2020-106587>
  12. Lee, J., Kim, H., & Park, S. (2021). Protective effects of respiratory equipment in preventing silicosis among mine workers. *Safety and Health at Work*, 12(2), 230-238. <https://doi.org/10.1016/j.shaw.2021.02.005>