

WHY ARE THE PARTICLES GENERATED BY ARTIFICIAL STONE MORE TOXIC THAN PARTICLES GENERATED BY NATURAL STONE?

SUMMARIES OF SIX STUDIES

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OVERVIEW

The respirable crystalline silica particles (RCS) generated from artificial stone have a more severe toxicologic profile than RCS generated from natural stone.

This helps explain why (compared to natural stone-associated silicosis) artificial stone-associated silicosis is characterized by short latency, rapid radiological progression, accelerated decline in lung function and high mortality (see Wu et al, 2020, below).

The toxicological characteristics of artificial stone include the following:

- High concentration of respirable particles: Cutting artificial stones generates much high concentrations of respirable crystalline silica content (>80%), whereas cutting natural stones produces respirable crystalline silica content of only 4-30%.
- Ultrafine particles: Cutting artificial stone produces high concentrations of ultrafine particles (< 0.1um in diameter), which exhibit very large reactive surface areas and enter the deep lung.
- Irregular shapes: Artificial stone particles show more irregular shapes with sharp edges and fractures along the surface compared to natural stone dust particles, which exhibit far fewer surface fractures. (MW: This could increase the rate of cell lysis, which leads to lung scarring).
- Sensitizing VOCs: During active cutting, the predominant volatile organic compound (VOC) emitted is styrene, with phthalic anhydride, benzene, ethylbenzene, and toluene also detected. Phthalic anhydride has a Respiratory Sensitization (RSEN) Notation by the ACGIH and has been the most abundant VOC identified, at 26–85% of the total VOC composition of artificial stone emissions. Benzaldehyde and styrene were also present in all twelve samples. Styrene is a respiratory irritant.
- Free radicals. Freshly cut RCS dust contains a high concentration of free radicals. A free radical is an atom or molecule containing one or more unpaired electrons in its outer orbit. This makes it unstable, short lived and highly reactive.

TWO EPIDEMIOLOGICAL STUDIES

- 1) **Artificial stone-associated silicosis in China: A prospective comparison with natural stone-associated silicosis. Wu, Xue, Yu and Ye, *Respirology* (2020) 25, 518–524**

In This Study:

- 18 patients with artificial stone-associated silicosis and 63 with natural stone-associated silicosis were diagnosed sequentially in 2018 and followed up for a period of 6–12 months. Data were collected from clinical charts.

Results:

- The median duration of exposure prior to onset of symptoms of silicosis was about 6 years for patients who had been exposed to artificial stone dust versus just under 30 years for onset of symptoms for patients who had been exposed to natural stone, a 5-fold difference.
- Four of the 18 patients exposed to artificial stone experienced rapid deterioration in lung function over the follow-up period of just 6—12 months, with declines in pre-bronchodilator FVC and FEV1 of about 600 mL/year.
- About 40% of the patients with artificial stone-associated silicosis were in need of lung transplants, and 28% died, whereas only 3.2% of natural stone-associated silicosis needed lung transplants and none died.

Conclusion:

- Compared to natural stone-associated silicosis, artificial stone-associated silicosis was characterized by short latency, rapid radiological progression, accelerated decline in lung function and high mortality.

2) León-Jiménez A, Hidalgo-Molina A, Ángel Conde-Sánchez M, et al. Artificial stone silicosis: rapid progression after exposure cessation. Chest. 2020;158(3):1060-1068.

In This Study:

- This is the first follow-up study of workers with advanced silicosis from exposure to respirable dust generated during the manufacture and installation of artificial stone (AS) countertops and other fixtures.
- Their cohort, originally described in 2014, now has had 4 years of follow-up.

Findings:

- The study demonstrated that silicosis from this exposure is aggressive and exhibits rapid progression in a high proportion of affected individuals.
- More than one-half of their patients showed radiographic progression by more than two subcategories of profusion, using the International Labour Office classification.
- Alarmingly, one-third of patients with simple pneumoconiosis advanced to progressive massive fibrosis after a mean of only 4 years of follow-up. The proportion of workers with abnormal spirometry also increased from one-quarter to nearly one-half of all workers over the same time period.

- Of great significance, all patients had been removed from continued exposure. These high rates of progression are in contrast to the lower prevalence of disease progression seen in granite workers as noted by the authors, or in former coal miners where, in one study, 10% had progression to progressive massive fibrosis over a mean of 22 years.

FOUR TOXICOLOGY STUDIES

1) Characterisation of dust emissions from machined engineered stones to understand the hazard for accelerated silicosis. Ramkissoon, Gaskin, Thredgold, Hall, Rowett & Gun. Scientific Reports, NaturePortfolio | (2022) 12:4351

In this study:

- In order to understand the hazard for the short latency of lung disease among stonemasons, we simulated *real-time* dust exposure scenario by dry-machining artificial stones in controlled conditions, capturing and analysing the *respirable* dust generated for physical and chemical characteristics. Natural granite and marble were included for comparison.

Findings:

- Cutting artificial stones generated high concentrations of respirable crystalline silica content (>80%), whereas cutting natural stones produces far lower respirable crystalline silica (4-30%).
- Artificial stone particles showed more irregular shapes with sharp edges and fractures along the surface than natural stone dust particles, which exhibited natural layers with less conchoidal fractures on the surface. (MW: This could increase the rate of cell lysis, which leads to lung scarring).
- Cutting artificial stone particles contained 8–20% polymeric resins, but this might have a protective effect of coating the surfaces of the artificial stone particles, previously demonstrated by Pavan et al. (see below).

2) Abrasion of Artificial Stones as a New Cause of an Ancient Disease. Physicochemical Features and Cellular Responses. Pavan, Polimeni, Tomatis, Corazzari, Turci, Ghigo, and Fubini. Toxicological Sciences, 153(1), 2016, 4–17

Summary:

- Researchers showed that artificial stone cutting produces highly reactive and potentially fibrogenic dusts in respirable size. These features may contribute, together with the high level of exposure recorded in these workplaces, to the high incidence of silicosis reported among these workers. It confirms the need for regulatory and preventive measures during processing of artificial stones
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3) Characterization of Silica Exposure during Manufacturing of Artificial Stone Countertops. Carrieri, Guzzardo, Farcas and Cena. International Journal of Environmental Research and Public Health. 22 June 2020

In This Study:

- Three artificial stone samples (A, B, and C) and one natural granite sample were subjected to cutting and grinding in a controlled environment.
- Gravimetric analysis, X-Ray diffraction, and scanning electron microscopy was employed to determine crystalline silica concentrations and particle morphology of bulk and respirable particles

Findings:

- Silica content of bulk dust from artificial samples A and B was 91%, sample C was <10%, while natural granite was 31%.
 - Silica percent in the respirable fraction for samples A and B was 53% and 54%, respectively, while sample C was <5% and granite was 8%.
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4) Ramkissoon, Gaskin, Hall, Pisaniello, Zosky (2023). Engineered Stone Fabrication Work Releases Volatile Organic Compounds Classified as Lung Irritants, *Annals of Work Exposures and Health*, Volume 67, Issue 2 (March 2023), pp 288–293.

In This Study:

- Researchers forensically screened the emissions from dry-cutting 12 artificial stone products in a test chamber for their organic composition

Findings:

- This study identified the presence of volatile organic compounds (VOC's), including styrene and phthalic anhydride, among the air contaminants released when artificial stone is fabricated.
- Phthalic anhydride has a Respiratory Sensitization (RSEN) Notation by the ACGIH, was the most common and abundant compound, at 26–85% of the total organic composition of artificial stone emissions. Benzaldehyde and styrene were also present in all twelve samples.
- During active cutting, the predominant volatile organic compound (VOC) emitted was styrene, with phthalic anhydride, benzene, ethylbenzene, and toluene also detected.
- These results have important health implications as styrene and phthalic anhydride are irritants to the respiratory tract. This study suggests a risk of concurrent exposure to high levels of respirable crystalline silica and organic lung irritants during artificial stone fabrication work.
- These substances may be responsible for some of the toxic effects on the airways of the lungs. These volatiles will not be removed by many filtering facepiece respirators.