Application of Mesoporous Silica Nanoparticles to Fire Debris Analysis

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Introduction

The analysis of fire debris is a critical aspect of fire investigations. Fire debris analysis is used to identify fuels and accelerants used in an arson or help determine the source of a fire.[1] During the analysis of a fire debris sample, absorbent materials, such as charcoal, are commonly used to extract trace amounts of volatile compounds from the sample.[1] Mesoporous silica nanoparticles (MSN) are porous, nanometer-sided particles that have very large surface areas and can be used as absorbent materials. In this study, the efficiency of MSN as an absorbent material in a simulated fire debris analysis was tested and compared to activated charcoal. Pieces of cloth wetted with toluene were used as model samples of fire debris. Extracts from MSN and activated charcoal were analyzed by gas chromatography-mass spectrometry (GC-MS).

Methodology

Mesoporous silica nanoparticles (MSN) were prepared as described by Lai et. al.[2] Two metal canisters each 11 Cm X 7.5Cm were used for the fire debris analysis (see Figures 1 and 2). 4 x 4 cm pieces of fabric wetted with toluene were used as model fire debris samples. 250 mg of activated charcoal and MSN were added to separate teabags and suspended from the top of the canisters. The bottom of the metal canisters contained the piece of fabric that was wetted with 1 mL of toluene. Each canister was tightly closed and heated in an oven for 15 minutes at a temperature of 90 °C. Once this process was completed, the teabags were placed in separate vials and 3 mL of acetone were added to each vial.

1.5 mL from each vial was placed in a centrifuge in order to separate the extracts from the MSN and charcoal. After the centrifuging process, 1 mL of each extract was placed in separate GC-MS vials and 25 uL of Ethyl Acetate was added to each vial and used as an internal standard. Each vial was then analyzed by the GC-MS and the data was collected. This process was repeated a total of three times in order to produce three trials of data to be analyzed for this experiment.

Figure 1

Figure 2

Results

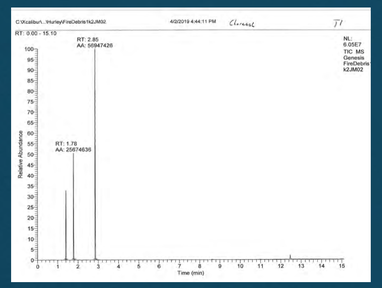

Figure 3

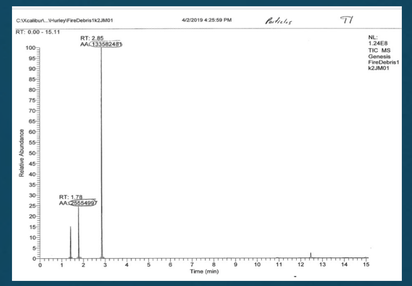

Figure 4

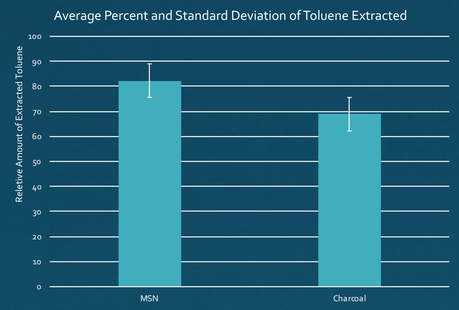

Figure 5

Discussion

Based upon the results, the MSN are more effective at extracting toluene from the samples than activated charcoal. The average relative amount of toluene extracted from the samples was 13.4% higher for MSN. Three trials were conducted in which the percentages of toluene extracted were collected and averaged together along with the standard deviation of each one.

Figure 3 and 4 display the chromatographs that were produced by the GC-MS. Each figure contains the retention times and peak area of toluene, acetone, and ethyl acetate for the respective substance analyzed. The peak area of the toluene was then divided by the sum of the peak area of toluene and ethyl acetate and that result was then multiplied by 100 to yield the relative amount of toluene extracted by both charcoal and nanoparticles.

Conclusion

It can be concluded based upon the data that was collected during this experiment, that Mesoporous Silica Nanoparticles are a more effective method of extracting traces of Toluene molecules from fire debris instead of activated charcoal. These molecules extracted 13.4% more toluene than activated charcoal.

References

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2. Lai, Cheng-Yu, et. al. "A Mesopourous Silica Nanosphere-Based Carrier System with Chemically Removable CdS Nanoparticle Caps for Stimuli-Responsive Controlled Release of Neurotransmitters and Drug Molecules." *Journal of American Chemical Society*, vol. 125, no. 15, 2003, pp. 4451–4459.

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