Scientists find bisulphates that curb efficacy of diesel engine catalysts

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A team of researchers from Yale-NUS College, in collaboration with scientists in Sweden, has found that bisulphate species in the exhaust stream are strongly connected to decreasing the effectiveness of exhaust remediation catalysts in diesel engines. Their findings pave the way for synthesising more sulphur-tolerant catalysts and developing regeneration strategies for catalyst systems on diesel-powered freight vehicles. This could lead to lower emission of highly toxic nitrogen oxides from diesel engines, hence reducing pollution.

Yale-NUS College postdoctoral fellows Susanna Liljegren Bergman and Vitaly Mesilov, undergraduate researcher Xiao Yang (Class of 2021), and Professor of Science (Chemistry) Steven Bernasek, carried out this research. They worked with collaborators Sandra Dahlin and Professor Lars Pettersson in Sweden, and Dr. Xi Shibo at the Singapore Synchrotron Light Source of the National University of Singapore. They utilised in-situ temperature-dependent Cu K-edge X-ray absorption spectroscopy to analyse exactly how sulphur oxides affect copper-exchanged chabazite framework (Cu-CHA) catalysts.

Catalysts composed of copper-exchanged zeolites with a chabazite framework (Cu-CHA) are currently the most efficient means to lower the emission of highly toxic nitrogen oxides from diesel engines. However, earlier studies showed that Cu-CHA catalysts' efficacy is reduced by sulphur oxides that are also present in diesel exhaust, which poses a problem as the catalysts become less effective at preventing nitrogen oxides from escaping into the atmosphere. In this study, the researchers found that the effectiveness of catalysts in diesel engines is most impacted by the presence or formation of bisulphates in the exhaust stream. Understanding the chemical mechanism of how catalysts in diesel engines are affected by sulphur oxides present in diesel exhaust would enable the development of more effective catalysts that could reduce the emission of nitrogen oxides from diesel engines.

With greater insight into the way sulphates affect catalysts, future work can be done to investigate how the negative effects can be mitigated. Additionally, the findings regarding sulphates may also be applied to other studies on the impact of phosphorous and phosphorous oxides, present in biodiesel fuel, on catalyst performance. This could lead to the creation of more effective catalysts for biodiesel-powered engines.

Prof Bernasek said, "The results of this fundamental research into the mechanisms of catalyst deactivation provide the basis for developing new catalysts and new catalyst regeneration protocols. More efficient and robust exhaust remediation catalysts benefit the environment by reducing the emission of nitrogen oxides and enabling the use of more efficient engines, cutting overall carbon emission. This helps to reduce the impact of the continued short-term use of fossil fuels, and speed our transition to carbon neutral biofuels."

More information: Susanna L. Bergman et al, In-situ studies of oxidation/reduction of copper in Cu-CHA SCR catalysts: Comparison of fresh and SO_2-poisoned catalysts, *Applied Catalysis B: Environmental* (2020). DOI: 10.1016/j.apcatb.2020.118722

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