diamond

Catalysis

CASE STUDY

Turning palm oil waste into biofuel

Indonesia is one of the largest suppliers of palm oil in the world, producing 42 million tonnes in 2018[1]. It is also experiencing an increase in car usage, coupled with a growth in imports of fuel.

To overcome this problem, the Indonesian government is driving a move to biofuels. Until recently the fresh fruit bunch from palm oil has successfully been used, however the empty fruit bunch (EFB) and palm kernel shell (PKS) provide a more sustainable source of lignocellulose, a key component in second generation biofuel production.

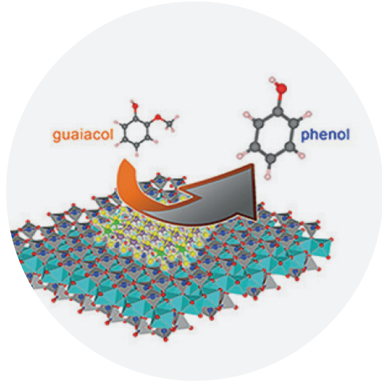
One prospective method for the biofuel production is conversion of lignocellulose into bio-oil via fast pyrolysis and then upgrading the bio-oil over a catalyst, to remove oxygen. However, the existing alumina-based and noble metal catalysts still suffer from catalyst deactivation due to carbon deposition and metal leaching.

[1] https://reut.rs/2EvVRyT

Newton Fund

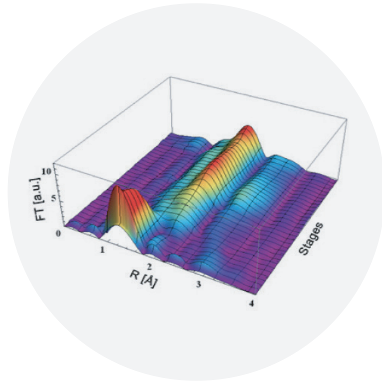
LIPI

The Challenge



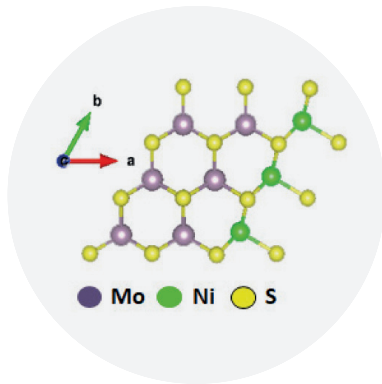
A bentonite-based catalyst, $NiMoS_2$/Al-PILC, developed by the Indonesian Institute of Sciences (LIPI) shows the potential application for biofuel production with its ability to achieve a high degree of deoxygenation (DOD) up to 65% using bio-oil derived lignocellulose feedstock - a 15% improvement on the commercial $NiMoS_2/Al_2O_3$ catalyst. Unfortunately, the active sites responsible for this effective hydrodeoxygenation (HDO) process and the exact role of aluminum pillared clay (Al-PILC) have not been well understood. Another concern about the catalyst's sensitivity to air to make it viable for commercial use remains unanswered. As analysis using diffraction techniques is impossible due to the non-crystalline nature of the catalyst, X-ray Absorption Spectroscopy (XAS) is the only feasible technique to understand its structure.

The Solution



LIPI and Diamond scientists conducted *in situ* XAS measurement at Mo K-edge, Ni K-edge, and Co K-edge. They were able to track down the gradual transition of the oxide-to-sulfide transformation of $NiMoS_2$ and $CoMoS_2$ catalysts. When directly exposed to steady air flow for one hour, both catalysts experienced mild oxide phase MoO_x formation that could be easily eliminated by re-sulfidation treatment.

By fitting Extended X-ray Absorption Fine Structure (EXAFS) data with density functional theory (DFT) models, the atom arrangement and distribution of promoter atoms Ni and Co in the catalyst can be fully determined. The findings suggest that the 2D structure of $NiMoS_2$ and $CoMoS_2$ adsorbed on Al-PILC might have an irregular structure instead of a regular hexagonal structure. Moreover, the result also indicates that no significant parts of Ni and/or Co atoms are oxidised during air exposure.



The Benefits

Using synchrotron techniques at Diamond, scientists were able to study the evolution of a $NiMoS_2$/PILC catalyst during activation. By understanding the structure, we can design much more effective catalysts, able to convert waste produce from Palm Oil into sustainable biofuels.

"Access to world class synchrotron XAS at Diamond has helped us to elucidate the exact structural geometry of our catalysts, not possible with lab-based diffraction techniques. This scientific knowledge is essential to unravel the complexity of chemical reactions that occur between bio-oil and the catalysts.The current work also demonstrates our first successful attempt to interpret EXAFS data using computational generated models." **Dr Ferensa Oemry,** Indonesian Institute of Sciences (LIPI)

For further information

Diamond Industrial Liaison Team

+44 1235 778797
diamond.ac.uk/industry
industry@diamond.ac.uk
@DiamondILO