Soil Properties Control Molybdenum Uptake by Wheat

Anthropogenic sources of molybdate can be taken up by wheat plants, especially from alkaline soils.

Molybdenum (Mo) is a micronutrient and functions as a cofactor in enzymes in both plants and animals. While its concentrations in the natural environment are low, recent studies have shown elevated levels of Mo in soils and waters near industrial parks in Taiwan.[1] The discharge of Mo into nearby agricultural lands may lead to excessive accumulation in plants and pose potential health risks. For example, excessive intake of Mo can cause chlorosis, yellowing, and reduced productivity in plants, as well as copper deficiency in livestock. With the growing demand for semiconductors, it is necessary to elucidate how soil properties control the chemical speciation of Mo in soils and its accumulation in plants. However, due to the low concentration of Mo in natural soils, examining its chemical species remains challenging; thus, the information available from previous studies is limited.

A recent study by Puu-Tai Yang and Shan-Li Wang (National Taiwan University) investigated Mo uptake by wheat plants grown in three Taiwanese soils.[2] Using X-ray absorption spectroscopy at **TPS 44A**, the research group found that Mo occurred primarily as sorbed Mo(VI) and Ca- and Fe-Mo(VI) precipitates (**Fig. 1**). The relative abundance of the Mo(VI) species varied with soil texture and pH. In acidic soils (Pc: pH 4.4, silty clay loam; Tn: pH 4.9, silty loam), sorbed Mo(VI) was the dominant species, followed by Fe-Mo(VI), with the clay-rich soil (Pc) containing a higher ratio of sorbed Mo(VI). In the alkaline soil (pH 8.2, silty clay loam), Mo presented mainly as Ca-Mo(VI). The decreases in sorbed Mo(VI) and Ca-Mo(VI) during cultivation suggested their availability to wheat plants.

The accumulation of Mo in wheat plants was highest in the alkaline soil (**Fig. 2**, see next page), consistent with the greater decrease in sorbed Mo(VI) during cultivation (**Fig. 1**). This finding is supported by the group's previous work, which showed that maximum molybdate sorption by soils is negatively correlated with soil pH.[3] Less Mo sorbed onto soils at higher pH could therefore result in greater Mo availability to plants.

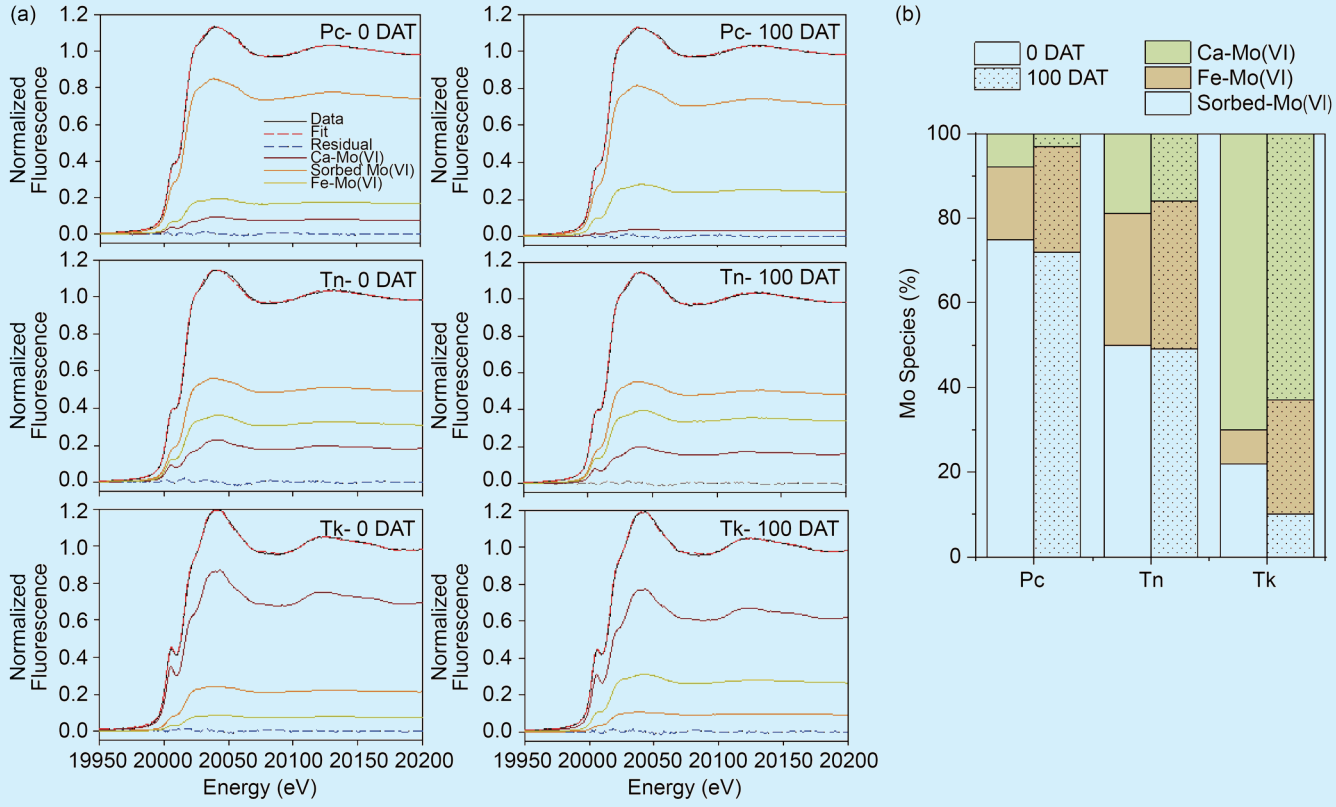

Fig. 1: Mo K-edge X-ray absorption near-edge structure spectra of Mo-spiked soil samples before (0 DAT) and after (100 DAT) wheat cultivation (a), and speciation determined by linear combination fitting (b). [Reproduced from Ref. 2]

In summary, the study demonstrated that the newly introduced Mo can significantly increase its concentration in wheat grain, posing a potential risk to human health. Identifying Mo species in soils using X-ray absorption spectroscopy provides valuable insight into the roles of soil properties in Mo accumulation in wheat plants. (Reported by Puu-Tai Yang, National Taiwan University)

This report features the work of Puu-Tai Yang and Shang-Li Wang published in J. Environ. Manage. ***374****, 124097 (2025).*

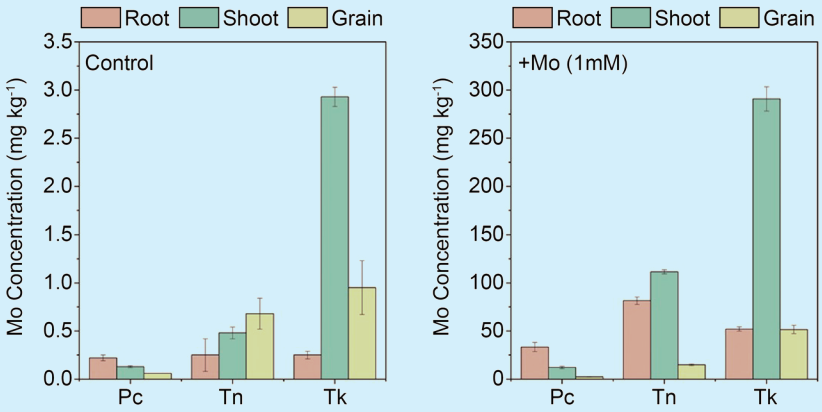

Fig. 2: Mo concentrations in the root, shoot, and grain of wheat plants grown in Pc, Tn, and Tk soils without (control) and with added Mo. [Reproduced from Ref. 2]

TPS 44A Quick-scanning X-ray Absorption Spectroscopy

- XAS
- Environmental Science, Soil Science, Chemistry

References

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From Atomic Dynamics to Industrial Efficiency: New Pathways for CO_2 Conversion

Catalytic function is governed by atomic-scale motion and interfacial charge control. Synchrotron X-ray techniques reveal both, enabling researchers to connect microscopic dynamics with macroscopic stability.

Carbon dioxide sits at the center of one of humanity's greatest paradoxes. It sustains life by regulating Earth's temperature and feeding plants through photosynthesis—yet in excess, it threatens our climate, our oceans, and our future. As scientists race to build a carbon-neutral world, the ability to transform CO_2 from a waste gas into a renewable feedstock has become a defining challenge of modern chemistry. In the race toward carbon neutrality, two recent breakthroughs, one published in *Nature* and the other in *Journal of the American Chemical Society*, improve our understanding of CO_2 conversion activated by catalysts, from the transient dynamics of single atoms to the structural endurance of industrial-scale alloys. These works led respectively by Hao Ming Chen (National Taiwan University) and Xile Hu (École Polytechnique Fédérale de Lausanne, Switzerland) bridge the gap between atomic-level dynamics and industrial-scale performance. Together, they form a comprehensive view of how catalysts function, adapt, and endure in the fight against climate change.

In the study reported in *Journal of the American Chemical Society*,[1] Chen and his team developed a series of atomically dispersed transition-metal–nitrogen–carbon catalysts (M–N–C), in which individual metal atoms such as Mn, Fe, Co, Ni, or Cu are anchored by nitrogen atoms on a carbon support. Each catalyst consists of metal–nitrogen fourfold sites ($M–N_4$). These materials are widely studied for electrochemical CO_2 reduction, a process that uses electricity to convert CO_2 into carbon monoxide (CO), which can be further processed into fuels or industrial feedstocks. Despite their structural similarity, the catalysts exhibited very different activities. Nickel- and manganese-based M–N–C showed particularly high selectivity and efficiency for CO production, while others were less active. To determine why, the researchers turned to *operando* quick-scanning X-ray absorption spectroscopy performed at **TPS 44A**, which is capable of monitoring the structural evolution of single metal atoms under working electrochemical conditions in real time. The data revealed