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Uncertainty in phosphine photochemistry in the Venus atmosphere prevents a firm biosignature attribution

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Context. The possible detection of phosphine (PH3) in the clouds of Venus has raised the question as to which processes could produce such large abundances of PH3. Previous studies suggested that abiotic processes including photochemical production cannot explain the claimed PH3 concentrations. However, the photochemistry of phosphorus-bearing species in the atmosphere of Venus is not well known.
Aims. We aim to assess the abiotic production of PH3 considering the effect of uncertainties in the chemical rate coefficients of phosphorus-containing reactions.
Methods. Using a photochemical column model, we simulated Venus-like conditions and varied the chemical rate coefficients with a Monte Carlo (MC) approach in order to estimate the associated error in the PH3 abundances throughout the atmosphere.
Results. Current uncertainties and missing data in photochemical rate coefficients lead to a variation of about six orders of magnitude in the modelled PH3 abundance on Venus, assuming photochemical production of PH3 from tetraphosphorus hexoxide (P4O6) pathways. Our results suggest an abiotically produced upper limit of 2 ppb PH3 between 50 and 60 km. These concentrations are in the range of a recent reanalysis of Atacama Large Millimeter Array (ALMA) data, suggesting planet-averaged abundances in PH3 of 1–4 ppb above 55 km. Future observations of phosphorus monoxide (PO) on Venus would be beneficial for increasing our confdence in assessing PH3 as a biosignature.
Conclusions. We conclude that due to the large uncertainties in phosphorus chemistry, even a firm detection of several ppb PH3 in the Venus atmosphere would not necessarily mean a biological origin.

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