

How to safely work with PH₃

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Phosphane PH₃ is the well-known analogue to ammonia NH₃. However, these derivatives show completely different properties. The E-H bonds of ammonia are best described using sp³ hybridized orbitals at the nitrogen center. On the contrary, phosphorous belongs to the “hybridization-reluctant” elements and the P-H bonds in PH₃ have a significantly higher p-orbital contribution which results in narrow H-P-H angles close to 90°.^[1] Another important difference is the ability to engage in E-H...A hydrogen bonding (A = hydrogen acceptor). While ammonia is highly soluble in water (up to 25 wt%) due to a high solvation energy caused by strong N-H...O bonds, phosphane is only soluble with 0.39 g L⁻¹.^[1] The aqueous solution of ammonia is safe to handle in the laboratory. Also, NH₃ gas can be liquified by the use of a dry ice bath. Handling phosphane on a laboratory scale is much more challenging.

Phosphane gas is toxic and is immediately dangerous to life and health (IDLH) at 50 ppm. It acts on the central nervous system and lungs, leading to pulmonary oedema.^[2] Ultra-pure phosphane is odorless, though it is mostly known for its garlic or rotten-fish smell, which originates from the dimer P₂H₄.^[2] Phosphane is spontaneously flammable at air. The boiling point of phosphane is at -87.7°C, which is below the one of commonly used cooling baths.^[1]

We build a setup for the safe handling of PH₃ in our laboratory at ETHZ. This setup was improved over the years in order to gain a safe and easy way in handling phosphane. The setup is shown in Fig. 1 and 2 and will be explained in detail in the presentation.



Figure 2: PH₃ setup in the fume hood including the quenching system.

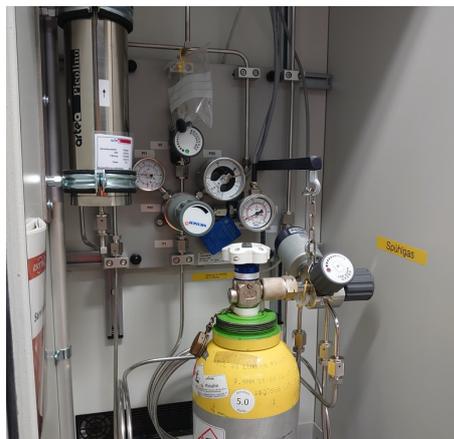


Figure 1: PH₃ cupboard.

[1] D. Corbridge, in *Studies in Inorganic Chemistry*, Vol. 20, Elsevier, **1995**, p. 1172.

[2] Md. S. Khan, *Chem Phys. Lett.*, **2015**, 636, 103-109.