X-ray absorption spectroscopy was used to study the local structure and chemical bonding of elemental phosphorus. Three allotropes of this element exist in the solid state. Crystalline black-P, a semiconducting material with an orthorhombic puckered layer structure, is the most stable allotrope. White-P, the least stable allotrope, is composed of tetrahedral P\(_4\) molecules. At room temperature it is a plastic crystal. Its structure is similar to α-Mn with the P\(_4\) molecules in the positions of the Mn atoms. The most common allotrope is the amorphous red-P. Like white-P it is composed of P\(_4\) molecules. In the gas phase tetrahedral P\(_4\) molecules are stable up to ~ 800 °C. At higher temperatures they decompose into P\(_2\) molecules that have a shorter P-P bond length and, like N\(_2\), a formal triple bond.

Theoretical P(1s) and P(2p) XAFS spectra of gaseous and solid state phosphorus were calculated by \textit{ab initio} FEFF and GSCF3 methods. These were compared and the spectral features were related to structural and electronic properties of the different allotropes of elemental phosphorus. The calculation results were then used to explain the features observed in the experimental P(1s) and P(2p) spectra of red-P, which were obtained at the DCM and Grasshopper beamlines of CSRF, respectively. They were measured simultaneously by total electron yield (TEY) and fluorescence yield (FY) with the incident photon beam at normal incidence to the sample surface.

The results of this study were presented at the XAFS 12 conference, held in Malmö, Sweden in June of 2003. A paper has been submitted to Physica Scripta to be published in the conference proceedings. A temperature dependent P(1s) EXAFS study of red-P is in progress to determine the Debye-Waller factor (the mean square deviation of the interatomic distance) of the first coordination shell in red-P.