Abstract for general public:

It is necessary to fulfill the rising global energy demand with clean sustainable fuels (that do not emit green house gases) in order to slow down major climate changes as predicted in near future due to global warming and also tackle the limited nature of fossil fuel reserves. Energy from the sun is one such clean, regularly available free resource and thus should be utilized as much as possible but it is discontinuous and not directly portable or storable. However, hydrogen fuel, being lightweight, and highly energy dense with clean combustion by-products (for e.g., water), is more suitable as an energy alternative. In fact, hydrogen is also a feed-stock in various industries and the global consumption is huge. Unfortunately, the present conventional production processes involve greenhouse gas emission. However, hydrogen can be easily produced by electrolysis of water, a widely present resource on earth. Water electrolysis happens in electrochemical cells which generally consist of 2 electrodes- an anode where water is oxidized to form oxygen and a cathode where water is reduced to form hydrogen, under the application of suitable voltage (>1.23 V). It is now well established that solar energy can be effectively harnessed by photo-electrochemical cells (where either or both electrodes can absorb light) to reduce this external voltage requirement in producing hydrogen. This reduced voltage may then be easily sourced from cheap solar cells instead of fossil fuels. The oxidation step at anode is a slow process and thus often limits the efficiency of the water splitting cells. Hence, significant research attention is given on the selection and development of photoanode (light absorbing anode) materials so that the technology can help hydrogen to compete with and replace conventional (and polluting) fuels. The chosen anode material of interest in this project is the popular considerably stable metal oxide, namely, tungsten oxide (WO_3) which can absorb a wide portion (both ultraviolet and visible light) of the sunlight. Additionally, WO_3 has the interesting but rarely explored capability of light induced charge storage (simultaneous with participation in photo-assisted water splitting) for continued H_2 production when it is dark. However, this exciting material still has some drawbacks, which lead to wastage of input energy and unwanted backward reaction (of H_2 and O_2 uniting back to water), thereby limiting overall performance. The proposed project aims to combine WO_3 with 2 low cost tungstates of earth abundant transition metals (Fe and Sn) such that these heterojunction photoanodes can result in the development of more efficient and durable photoelectrochemical cells. These two combinations have been previously suggested by researchers as promising but not explored practically. The tungsten oxide photoanodes will be developed by a reproducible and scalable technique, which grows porous high surface area materials so that the amounts required can be decreased and component miniaturization is possible for commercialization. This method, namely anodic oxidation of metals, is still less reported with respect to heterojunction electrode preparation and has ample scope for investigation. We hope to optimise the electrode materials and demonstrate stable near 0 volt operation with reasonably high rate of output for some hours (due to enhanced corrosion resistance). Research in this field is urgent so that faster technology transfer from laboratory to the industries is possible. Apart from the incorporation of photoanodes in the conversion of solar to hydrogen energy, these may also find use in light-assisted energy storage devices of recent interest where solar energy is directly converted to other storable forms for e.g., as chemical energy in batteries/supercapacitors.