Integration of semiconductor mineral and bacteria for treating environmental pollutants

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Rutile is one type of titanium oxide (TiO_2) minerals that widely exist in natural and is a well known semiconductor. Under light irradiation, electrons in TiO_2 are excited from the valence band to the conduction band, leaving behind the same number of holes in the valence band. The photon-excited electrons flee into the surrounding environment and can participate in reducing reactions. The holes left behind posses oxidizing potential of accepting electrons, and can be involved in oxidizing reactions. The photocatalytic activity of naturally occurring rutile can be just as high, due to its content of trace metals such as vanadium (V), iron (Fe), zinc (Z) and copper (Cu). These trace metals caused "impurities" in the crystal lattice of rutile, generating energy bands that enhance the light absorbance and broaden the spectral responding range.

Bacteria have been well known for their involvement in electron transfer and oxidation and reduction of organic and inorganic compounds. This study focused on *Thiobacillus ferrooxidans (T.f.)*, an autotrophic bacterium that has been found widely existing in acidic environments such as mines and other geological formations.

We designed a device to investigate rutile mediated transfer of photon-excited electron and its interactions with bacteria. A dual-chambered fuel cell was constructed with a glass tubing and a pinch clamp assembly. The chambers were physically separated by proton exchange membrane. The anode consisted of an unpolished graphite. The cathode consisted of a mineral-coated polished graphite with the same size of the anode. The electrodes were connected with a copper wire by drilling holes in the graphite electrodes. The holes were filled with a nonconductive epoxy. The upper edge of the electrodes did not come into connect with the solution in each chamber during the total experimental time.

In this study, we hypothesized that extraneous electrons involved in *T.f.* metabolism and the cell growth may be provided by photon-excited electrons. There are dozens of semiconductor minerals of similar photocatalytic activity widely existing in nature. Other natural electron shuttle includes pigments, metabolic intermediates and other inorganic and organic compounds. With the abundance of all these components, it is convincing that the interactions of microorganisms with sunlight through mediation of semiconductive minerals may be ubiquitously occurring in nature. The case studies for treating environmental pollutants are also showed here more detail.

The characteristics of the tin-bearing granites in the middle of Nanling Range, South China

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The large-scale tin mineralization is closely related to granites formed in the Late Jurassic period in the middle Nanling Range, South China. These granites including Huashan-Guposhan, Jiuyishan, Qitianliang, Qilishan and Xitian plutons are distributed along the Chenzhou-Linwu fault and have an age range of 145 Ma to 165 Ma. The rock types are dominated by hornblende biotite monzogranite, biotite monzogranite and two micas granite. The tin deposits related to the granites, such as Daao, Furong, Shizhuyuan and Xitian deposits, occurred between 149 Ma and 161 Ma.

The biotite, sphene and rutile in these granites have the higher tin contents, which can be considered as an indicator for ore-forming potential of the granites. As an example, the tin abundances of biotite, sphene and rutile in the Qitianlin granites related to the Furong tin deposit are 0.07 wt%, 0.14~1.14 wt% and 0.23~10 wt%, respectively.

Compared with the tungsten-bearing granites in the Nanling Range, South China (Chen J *et al*. 2008), the tin-bearing granites display an unique geochemical features. These tin-bearing granites have values of 66.20~77.98 wt% for SiO_2, 0.07~0.89 wt% for TiO_2 and 7.22~9.62wt% for K_2O+Na_2O, and are metaluminous-weakly peraluminous. They are characterized by enrichment of REE (192~626 ppm), Zr+Nb+Ce+Y (270~690 ppm) and Ba+Sr (133~957 ppm) and the lower content of Rb (249~595ppm). The granites have the higher ratios of $CaO/(K_2O+Na_2O)$ and LREE/HREE, with 0.04~0.41 and 3~16 respectively. The ratios of Al_2O_3/TiO_2 and Rb/Sr are lower in such rocks and range from 15 to 171 and from 1 to 55, respectively. These characteristics indicate that the granites related to the tin deposits underwent weaker differentiation and evolution. The initial $^{87}Sr/^{86}Sr$ ratios of the granites vary from 0.7063 to 0.7182, $\varepsilon_{Nd}(t)$ values from -1.7 to -8.0 and t_{2DM} values from 1.1 to 1.6 Ga, which implies that the source materials were derived from the Proterozoic continent crust and the different proportions of mantle component were involved in them.

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