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REDUCTIVE DECHLORINATION OF POLYCHLORINATED BIPHENYLS (PCB) BY MEANS OF NANOSCALE ZEROVALENT NICKEL-IRON (NZVNI) PARTICLES

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Abstract

Polychlorinated biphenyls (PCBs) are a family of toxic and highly recalcitrant compounds which contaminate sediment and soils. PCBs are very stabile and can be degraded in the presence of expensive catalizers, such as bimetallic Fe/Pd particles, only at high temperature. Nanoscale ZeroValent Iron (NZVI) are promising catalysts since they are able to supply the reducing potential (releasing hydrogen) needed for chemical dechlorination of some chlorinated aromatics. Bimetallic Nanoscale ZeroValent Nickel-Iron (NZVNI) particles proved even more reactive than NZVI and are also much cheaper than Pd.

The capability of NZVI and NZVNI particles to degrade/dechlorinate PCB were tested in water and water/methanol systems. For this purpose, NZVI (Fe^0 1.67 g/L) or NZVNI (Fe^0 1.67; Ni° 0.88 g/l) particles were added in bottles containing either water or water/methanol 70/30 (v/v). A single PCB congener (2,3,4,5-CB) was added, at the final concentration of 2 mg/L, into bottles which were incubated under orbital shaking (150 rpm) at 28°C for 8 weeks.

No dechlorination was observed in any of the NZVI amended systems throughout incubation. Therefore, the reactivity of Fe^0 nanoparticles proved not to be sufficient to sustain PCB dechlorination at low temperature. On the contrary NZVNI proved effective in dechlorinating PCB even under the abovementioned mild condition. In particular, NZVNI bimetallic nanoparticles caused a percentage of 2,3,4,5-CB depletion of 5.2±1.8 in water solution. In water/methanol containing bottles NZVNI leaded to a more extensive dechlorination, as 2,3,4,5-CB concentration was reduced of 7.8±0.4 of its initial amount. This difference is possibly be due to the very limited solubility of PCBs in water, slightly improved by the presence of methanol as co-solvent so as to allow a more effective interaction with the catalyst. Gas-chromatographic analyses revealed the transient accumulation of 2,3,4,5-CB dechlorination products (tri-, di- and mono- chlorinated PCBs), thus confirming the actual reduction of the initial substrate.

In conclusion, bimetallic Ni/Fe Nanoscale ZeroValent particles can be used to dechlorinate 2,3,4,5-CB in methanol/water systems even at room temperature and in easy to handle lab conditions. Although the dechlorination is far from being complete and an optimization of the process must be pursued, these results indicate that NZVNI particles are a promising catalyst for the development of strategies aimed at degrading dangerous and stable pollutants such as PCBs.