similarity with *Penicillium expansum*. The ability of strain QQ for azo dyes removal was investigated. It showed that stain QQ was able to decolorize different type azo dyes, such as Reactive Red X-3B, Acid Red B, Reactive brilliant red KE-3B, etc. Both of Reactive Red X-3B and Acid Red B could be decolorized absolutely by stain QQ during 48 h. Also, it could use some aromatic compounds as sole carbon and energy source, i.e. biphenyl, phenol, naphthalene and so on. The optimal conditions for both growth and decolorization process was determined as pH, temperature, carbon source and salt concentration. For the view of these results, strain *Penicillium* sp. QQ would be an efficient microbial inoculate for various azo dyes treatment process in field application.

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VII5-P-020

Biodegradation of phenolic compounds by the mixed culture of *Arthrobacter* sp. and *Candida* sp. under high salt conditions

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Biodegradation of phenolic compounds (phenol and *p*-cresol) by the mixed culture of *Arthrobacter* sp. and *Candida* sp. under high salt conditions (NaCl 5%) was investigated in the present paper. Both phenol and *p*-cresol could be utilized by the consortium as the sole carbon and energy sources. The microbial consortium could degrade 1000 mg L^{-1} phenol within 52 h and 500 mg L^{-1} *p*-cresol within 57 h, respectively. When cells grew on the mixture of phenol and *p*-cresol, strong substrate interactions were observed. It was showed that biodegradation of *p*-cresol (50–200 mg L^{-1}) could be significantly enhanced by addition of a little phenol (50 mg L^{-1}). However, biodegradation of phenol was inhibited by the addition of same amount of *p*-cresol. The intrinsic kinetics of biodegradation process was also investigated, which suggested that the biodegradation was conformed to the substrate-inhibited equation. In addition, the effects of combination of NaCl, KCl, Na_2SO_4 and K_2SO_4 on degradation of mixed substrates were studied. It exhibited that microbial consortium possessed higher efficiency than that of single microorganism itself. In a conclusion, the method combined *Arthrobacter* sp. and *Candida* sp. is useful for treatment of wastewater containing phenolic compounds under high salt conditions.

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VII5-P-021

Development of a bioluminescent whole-cell biocatalyst by displaying functional fusions on the surface of *Escherichia coli*

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At present, Lpp-OmpA-mediated surface display has opened a new dimension in the development of whole-cell factories (Earhart, 2000; Francisco et al., 1992). Here we report the surface display of methyl parathion hydrolase (MPH) and green fluorescent protein (GFP) fusions (60 kDa) by employing the Lpp-OmpA chimera as an anchoring motif. A broad-host-range vector, pLOMG33, coding for Lpp-OmpA–MPH–GFP fusion protein was constructed for targeting the fusion protein onto the surface of *Escherichia coli*. The surface localization of fusion protein was demonstrated by Western blot analysis, immunofluorescence microscope and protease accessibility experiment. The surface-exposed fusion protein retains the MPH activity and GFP fluorescence. Anchorage of macromolecule fusions on the outer membrane neither inhibits cell growth nor affects cell viability, as shown by growth kinetics of cells and stability of resting cultures. The engineered *E. coli* with surface-expressed MPH–GFP has two major advantages over the same strain expressing cytosolic MPH–GFP, including 7-fold higher whole-cell activity and 2-fold stronger fluorescence. Moreover, the construct pLOMG33 can potentially be applied to various bacterial species for enhancing field use. This is the first report on the presentation of GFP fusions on the cell surface by Lpp-OmpA. Our results suggest that Lpp-OmpA is a useful tool for functional display of macromolecule passenger proteins on the cell surface.

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VII5-P-022

Accumulation of lead(II) by an exopolysaccharide producing *Bacillus licheniformis* X14

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An exopolysaccharide producing *Bacillus licheniformis* X14 was tested for its Pb(II) tolerance. This isolate was not only resistant to this heavy metal but also showed enhanced growth and exopolysaccharide production in the presence of Pb(II) at 25, 50 and 100 mg/L concentrations. XRF analysis of both the biomass as well as the exopolysaccharide revealed that a sum total of bout 90–95% lead was accumulated by this bacterium. FTIR spectra indicated the binding characteristics of the lead ions involved the carboxyl, hydroxyl and amino groups in the biomass. Surface adsorption of the metal at surface of exoplysaccharide and cells was confirmed through scanning electron microscopy. This indicated that this organism could prove to be a potential candidate in the field of bioremediation with respect to lead removal.

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VII5-P-023

Biosorption of lead(II)from aqueous solution using immobilized *Bacillus lichenifromis* X14

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The biosorption of lead(II) ions from aqueous solution by immobilized dead *Bacillus licheniformis* X14 cells was investigated. The effects of contact time, biosorbent dose, the initial pH, lead ions concentration and the presence of copper or/and zinc ions were studied. The experiments results showed that the immobilized *B. licheniformis* cells were effective in removing lead ions from aqueous solution. The biosorption was significantly affected by the initial pH, lead ions concentration and biosorbent dose. The presence of copper, zinc or both metals in aqueous solution suppressed the removal of lead ions. The experimental isotherm data were then modeled using Langmuir and Freundlich isotherm equations. As a result, the Langmuir and Freundlich isotherm yielded the best fit of experimental data. Kinetics experiments showed the biosorption of lead was a rapid process and the pseudo-second-order model was successfully.

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VII5-P-024

Screen and characteristics of a denitrifying phosphorus-removal bacteria

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Compared with the traditional polyphosphate-accumulating organisms (PAOs), denitrifying P-removal bacteria (DPB) could remove P and N simultaneously (Barak and van Rijn, 2000). However, it was difficult to isolate the DPB pure culture (Wachtmeister et al., 1997). The objectives of this paper were: (i) to screen and identify DPB from high P-removal activated sludge and (ii) to investigate DPB's growth and characteristics of P/N removal. Compared with conventional P-removal examinations, denitrifying ability tests, PHB-staining, poly-P-staining and P-removal examinations were used to screen the DPBs. DPB was identified by Combining MIDI Fatty acid Analysis with phylogenies analysis. The growth of DPB was determined by photo-electric colorimetry. The isolated DPB b204 was cultured with nitrite, oxygen and nitrate to examine the P-removal under different electron acceptor conditions. The AFM results showed that b204 was short bacillus with width of 0.5–1.2 μm and length of 1.4–2.8 μm. After MIDI Fatty acid Analysis and phylogenies analysis, b204 was identified as the *Pseudomonas stutzeri*. The Generation time and the specific growth rate were calculated to be 4.5 h and 0.154 h^{-1}.The isolated DPB strain b204 grew faster than other reported PAOs. In P-removal process, P-removal was regularly associated with N-removal. b204's removal efficiency of P, NO_3–N and NO_2–N achieved 90.25%, 90.5% and 91.8%, respectively, after 26 h cultivation. In different electron acceptors test, b204 can use all three kinds of electron acceptors and the phosphorus uptake rate was almost identical. This result of pure isolated b204 culture was similar to the sludge batch experiment. It achieved good Denitrifying P-removal effect. This work of isolated pure typical DPB can help people know more about denitrifying P-removal process in detail and may be benefit to further research.

Keywords: Polyphosphate-accumulating organisms; Denitrifying P-removal bacteria; Growth characteristic; Electron acceptors; Phylogenetic analysis