Immobilization of Laccase on Magnetic Mesoporous Silica Nanoparticles for Enhancing Biocatalysis

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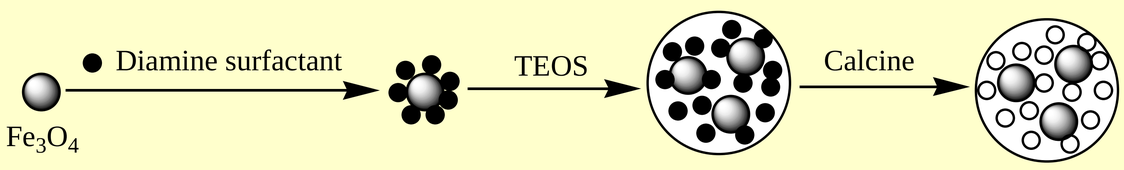
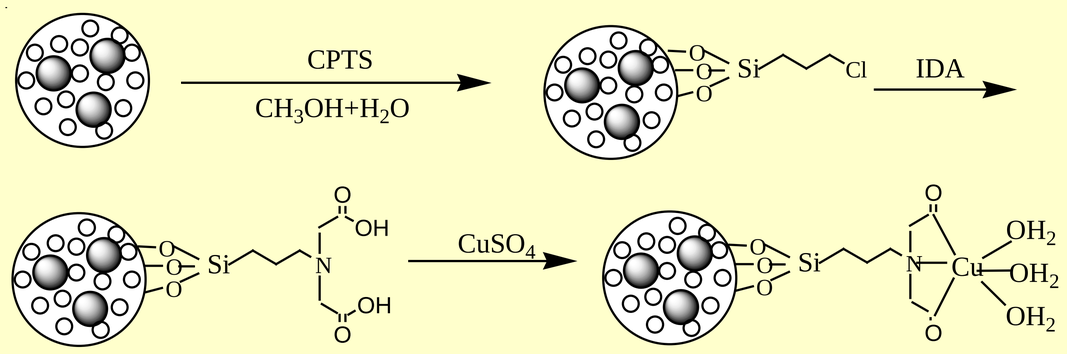
Large-pore magnetic mesoporous silica nanoparticles (MMSNPs) with wormhole framework structures were synthesized by using tetraethyl orthosilicate as the silica source and amine-terminated Jeffamine surfactants as template. Iminodiacerate was attached on these MMSNPs through a silane-coupling agent and chelated with Cu^{2+}. The Cu^{2+}-chelated MMSNPs (MMSNPs-Cu^{2+}) showed higher adsorption capacity of 98.1 mg g^{-1}-particles and activity recovery of 92.5% for laccase via metal affinity adsorption in comparison with MMSNPs via physical adsorption. Storage stability and temperature endurance of the adsorbed laccase on MMSNPs-Cu^{2+} increased significantly, and the adsorbed laccase retained 86.6 % of its initial activity after 10 successive batch reactions operated with magnetic separation. The immobilized laccase on the magnetic mesoporous silica nanoparticles has been developed for efficient phenol degradation. The degradation rate of phenol by the immobilized laccase was 2-fold higher than that of the free laccase, and the immobilized laccase retained 71.3 % of its initial degradation ability after 10 successive batch treatments of coking wastewater. The phenol degradation in the coking wastewater was enhanced in a continuous treatment process by the immobilized laccase in a magnetically stabilized fluidized bed because of good mixing and mass transfer.

➢ MMSNPs-Cu^{2+} Fabrication

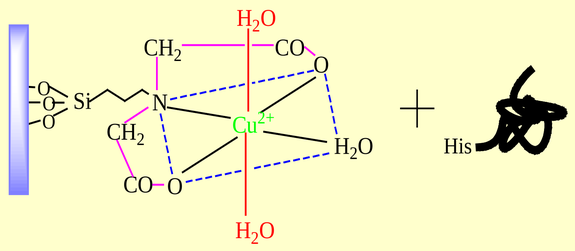
（1）Magnetic mesoporous silica nanoparticles (MMSNPs)

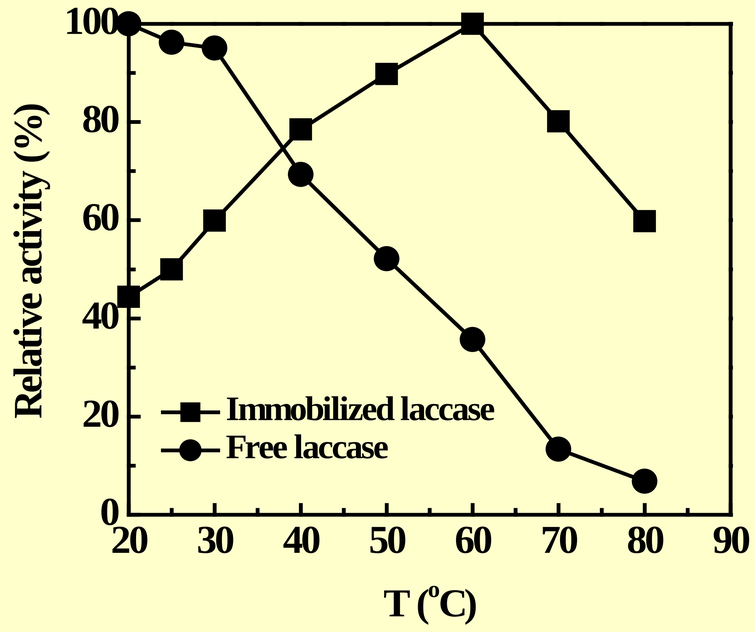


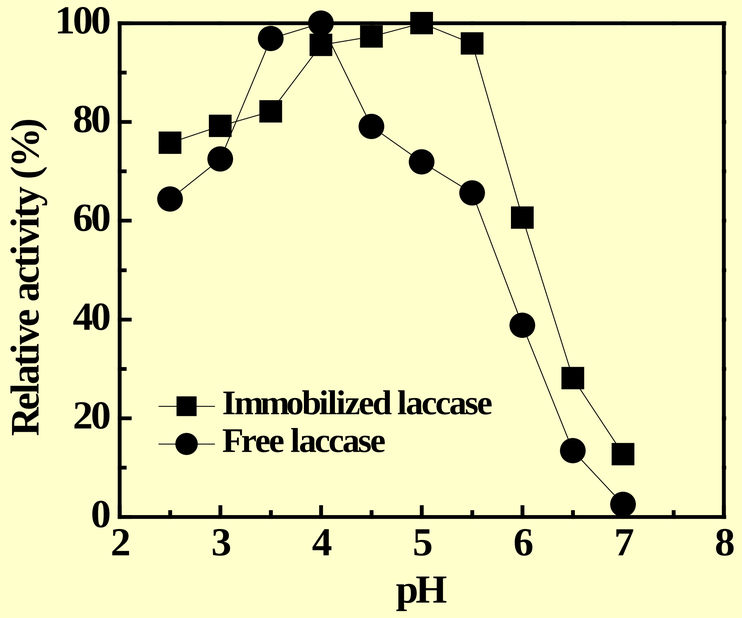
（2） Cu^{2+}-chelated MMSNPs



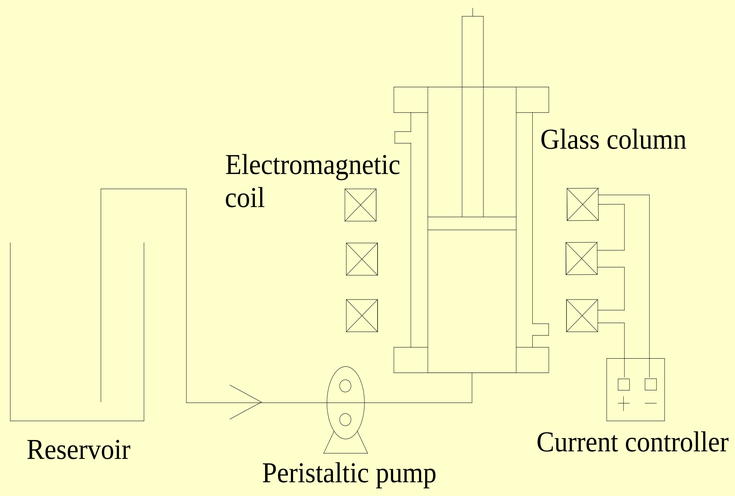
➢ Laccase Immobilization



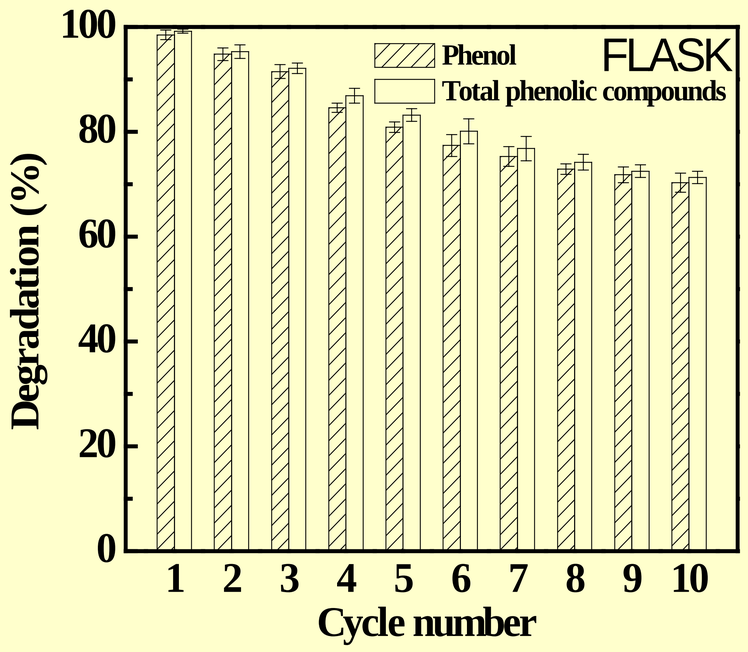


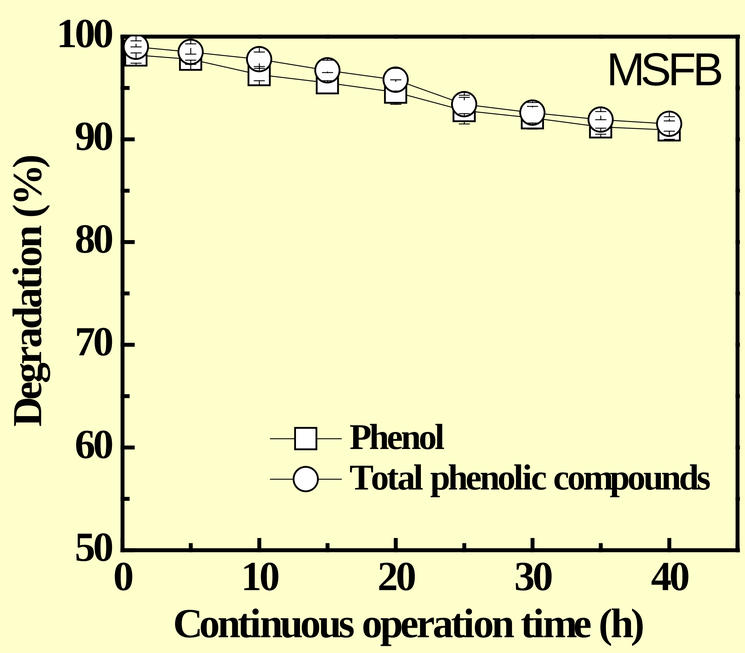


➢ Phenol Biodegradation



Magnetically Stabilized Fluidized Bed (MSFB)





Operation model and system	Residual laccase activity	Degradation efficiency	
	(%)	Phenol (mg h^{-1})	Total phenolic compounds (mg h^{-1})
Batch treatment in flask	71.8	80.4	124.2
Continuous treatment in MSFB	92.8	126.6	192.5