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Content list available at: www.benthamopen.com/TOBIOTJ/

DOI: 10.2174/1874070701610010289

Biosurfactant Production and Biodegradation of Leather Dust from Tannery

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Table 1. Concentration of chromium detected in the cell free supernatant during incubation with *Bacillus subtilis* SA-6 for 10 days (mg/L) for repeat 1.

Sample repeat 1	NB		NBBS		NBCR		NBLD		NBBSCR		NBBSLD		NBBSCRLD	
Time	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs
0	0.491	0.001	0.0014	0.001	1.035	0.040	0.120	0.010	1.563	0.050	0.042	0.010	1.319	0.040
24	0.564	0.000	0.006	0.001	1.263	0.040	2.585	0.080	1.697	0.050	48.910	1.260	97.625	1.700
48	0.3246	0.010	0.0242	0.002	1.404	0.050	4.326	0.130	1.595	0.050	173.210	4.90	274.240	7.70
120	0.0604	0.003	0.0062	0.001	1.349	0.050	8.966	0.260	1.736	0.060	192.280	5.500	181.760	5.20
144	0.1563	0.005	0.0006	0.001	1.338	0.050	10.233	0.290	1.709	0.050	194.300	5.500	157.040	4.500
168	0.1707	0.006	0.0116	0.001	1.361	0.050	11.622	0.330	1.638	0.050	192.900	5.500	126.850	3.600
192	0.2173	0.007	0.0076	0.001	1.407	0.050	13.168	0.380	1.829	0.060	200.630	5.70	158.870	4.50
216	0.3922	0.012	0.0011	0.001	1.443	0.050	14.804	0.420	1.895	0.060	200.760	5.700	163.060	4.600

Table 2. Concentration of chromium detected in the cell free supernatant during incubation with *Bacillus subtilis* SA-6 for 10 days (mg/L) for repeat 2.

Sample repeat 2	NB		NBBS		NBCR		NBLD		NBBSCR		NBBSLD		NBBSCRLD	
Time	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs
0	0.0083	0.000	0.0192	0.001	1.764	0.050	0.080	0.000	1.570	0.050	0.220	0.010	1.772	0.060
24	0.0439	0.002	0.0246	0.001	1.760	0.050	3.114	0.090	1.539	0.050	35.967	1.000	72.184	1.820
48	0.028	0.001	0.0292	0.001	1.782	0.050	5.008	0.140	1.525	0.050	134.870	4.600	163.270	5.500
120	0.0313	0.001	0.036	0.001	1.881	0.050	10.40	0.280	1.640	0.060	169.930	5.700	150.350	5.100
144	0.0243	0.001	0.027	0.001	1.822	0.050	12.164	0.330	1.656	0.060	201.189	6.800	152.470	5.100
168	0.0263	0.001	0.026	0.001	1.830	0.050	13.054	0.350	1.709	0.060	178.800	6.000	152.520	5.100
192	0.0366	0.002	0.0293	0.001	1.862	0.050	19.840	0.540	1.726	0.060	181.610	6.100	157.680	5.300
216	0.0567	0.002	0.0231	0.001	1.990	0.060	21.523	0.580	1.757	0.060	193.660	6.500	160.360	5.400

Table 3: Concentration of chromium detected in the cell free supernatant during incubation with *Bacillus subtilis* SA-6 for 10 days (mg/L) for repeat 3.

Sample repeat 3	NB		NBBS		NBCR		NBLD		NBBSCR		NBBSLD		NBBSCRLD	
Time	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs	Cr conc (mg/L)	Abs
0	0.0479	0.001	0.0656	0.001	2.369	0.030	0.126	0.003	1.530	0.040	0.1369	0.003	1.692	0.040
24	0.0779	0.000	0.0664	0.001	2.500	0.030	2.517	0.060	1.584	0.040	48.362	1.020	78.321	1.620
48	0.0582	0.001	0.0664	0.001	2.493	0.030	3.994	0.090	1.600	0.040	191.760	4.300	183.090	4.100
120	0.0647	0.001	0.0638	0.001	2.735	0.040	8.639	0.200	1.637	0.040	210.210	4.700	159.670	3.600
144	0.0696	0.001	0.0657	0.001	2.686	0.040	9.996	0.230	1.797	0.040	209.880	4.700	203.600	4.600
168	0.0612	0.001	0.0672	0.001	2.618	0.040	11.242	0.250	1.786	0.040	209.640	4.700	136.570	3.100
192	0.0666	0.001	0.070	0.001	2.733	0.040	12.773	0.290	1.731	0.040	217.420	4.900	217.190	4.900
216	0.0719	0.001	0.0798	0.000	2.858	0.040	12.924	0.290	1.409	0.030	230.03	5.200	193.810	4.300

Nutrient broth (NB), Nutrient broth+*Bacillus subtilis* (NBBS), Nutrient broth+Chromium (NBCR), Nutrient broth+Leather dust (NBLD), Nutrient broth+*Bacillus subtilis*+Chromium (NBBSCR), Nutrient broth+*Bacillus subtilis*+Leather dust (NBBSLD), Nutrient broth+*Bacillus subtilis*+Chromium+Leather dust (NBBSCRLD).

Table 4: Descriptive statistics for comparisons of detoxification of leather dust experimental groups on the rate of chromium concentration increase between 0-24 h.

Descriptives								
Rate (mg/L/h)								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
NB	3	.001750	.0010897	.0006292	-.000957	.004457	.0010	.0030
NBBS	3	.000143	.0000981	.0000567	-.000100	.000387	.0000	.0002
NBCR	3	.004833	.0047522	.0027437	-.006972	.016638	.0000	.0095
NBLD	3	.409667	.5079590	.2932703	-.852173	1.671507	.1030	.9960
NBBSCR	3	.009500	.0116512	.0067268	-.019443	.038443	.0000	.0225
NBBSLD	3	1.846667	.3092464	.1785435	1.078456	2.614877	1.4900	2.0400
NBBSCRLD	3	3.376667	.5636784	.3254399	1.976412	4.776921	2.9300	4.0100
Total	21	.807032	1.2768275	.2786266	.225827	1.388237	.0000	4.0100

Table 5. One-way ANOVA analysis of all experimental groups on the rate of chromium concentration increase between 0-24 h.

ANOVA					
Rate (mg/L/h)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31.263	6	5.210	54.312	.000
Within Groups	1.343	14	.096		
Total	32.606	20			

Table 6. One-way ANOVA analysis of NBLD, NBBSLD, NBBSCRLD experimental groups on the rate of chromium concentration increase between 0-24 h.

ANOVA					
mg/L/h					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.209	2	6.604	29.511	.001
Within Groups	1.343	6	.224		
Total	14.552	8			

Table 7. Comparison of means between NBLD, NBBSLD and NBBSCRLD groups between 0-24 h using the Dunnet test.

Multiple Comparisons						
Dependent Variable: mg/L/h						
Dunnett t (2-sided)[a]						
					95% Confidence Interval	
(I) Culture	(J) Culture	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
NBBSLD	NBLD	1.43700*	.38626	.017	.3312	2.5428
NBBSCRLD	NBLD	2.96700*	.38626	.000	1.8612	4.0728

*. The mean difference is significant at the 0.05 level.

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table 8. Descriptive statistics for comparisons of detoxification of leather dust experimental groups on the rate of chromium concentration increase between 24-48 h.

Descriptives								
Rate (mg/L/h)								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
NB	3	-.0037	.00546	.00315	-.0173	.0099	-.01	.00
NBBS	3	.0067	.01149	.00663	-.0218	.0353	.00	.02
NBCR	3	.0029	.00441	.00254	-.0080	.0139	.00	.01
NBLD	3	.0700	.01000	.00577	.0452	.0948	.06	.08
NBBSCR	3	-.0014	.00248	.00143	-.0076	.0047	.00	.00
NBBSLD	3	5.0967	.92781	.53567	2.7919	7.4015	4.13	5.98
NBBSCRLD	3	5.2967	1.84641	1.06603	.7099	9.8834	3.80	7.36
Total	21	1.4954	2.48683	.54267	.3634	2.6274	-.01	7.36

Table 9: One-way ANOVA analysis of all experimental groups on the rate of chromium concentration increase between 24-48 h.

ANOVA					
Rate (mg/L/h)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	115.146	6	19.191	31.458	.000
Within Groups	8.541	14	.610		
Total	123.686	20			

Table 10. One-way ANOVA analysis of NBLD, NBBSLD, NBBSCRLD experimental groups on the rate of chromium concentration increase between 24-48 h.

ANOVA					
Rate (mg/L/h)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52.625	2	26.313	18.486	.003
Within Groups	8.540	6	1.423		
Total	61.166	8			

Table 11: Comparison of means between NBLD, NBBSLD and NBBSCRLD groups between 24-48 h using the Dunnet test.

Multiple Comparisons						
Dependent Variable: Rate (mg/L/h)						
Dunnett t (2-sided)[a]						
					95% Confidence Interval	
(I) Culture	(J) Culture	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
NBBSLD	NBLD	5.02667*	.97413	.004	2.2380	7.8154
NBBSCRLD	NBLD	5.22667*	.97413	.003	2.4380	8.0154

*. The mean difference is significant at the 0.05 level.

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Nutrient broth (NB), Nutrient broth+*Bacillus subtilis* (NBBS), Nutrient broth+Chromium (NBCR), Nutrient broth+Leather dust (NBLD), Nutrient broth+*Bacillus subtilis*+Chromium (NBBSCR), Nutrient broth+*Bacillus subtilis*+Leather dust (NBBSLD), Nutrient broth+*Bacillus subtilis*+Chromium+Leather dust (NBBSCRLD).

Table 12: Rate of chromium concentration increase between 0-24 h and 24-48 h.

0-24 h	Rate mg/L/h (Average±Standard deviation)	24-28 h	Rate mg/L/h (Average±Standard deviation)
NB	0.0018±0.0011	NB	0.0037±0.0055
NBBS	0.0001±0.0001	NBBS	0.0067±0.0114
NBCR	0.0048±0.0048	NBCR	0.0029±0044
NBLD	0.4097±0.5079	NBLD	0.07±0.01
NBBSCR	0.0028±0.0030	NBBSCR	0.0014±0.0024
NBBSLD	1.8467±0.3092	NBBSLD	5.097±0.9278
NBBSCRLD	3.3767±0.5637	NBBSCRLD	5.1767±1.9122