Influence of Chemical Composition of Activated Sodium Bentonites on Degummed Palm Oil Bleaching

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Abstract

The efficiency of clays in bleaching degummed palm oil depended on their unique characteristics. The characteristics of bentonites and Na-bentonites, including activated forms of both clays, were investigated in depth to determine their bleaching capacity. The results showed that Na–bentonite treated with 1.5 M H_2SO_4 at a clay:acid ratio of 10:50 (w/v) and refluxing time of 8 h had higher bleaching capacity (78.04%) than commercial clay (67.09%). X-Ray Diffraction (XRD) patterns of bentonites and Na-bentonites activations show peaks similar to montmorillonite. Meanwhile, X-ray Fluorescence Spectrometry (XRF) indicated a correlation between the SiO_2 and Al_2O_3 contents of clays and their bleaching capacity. Interestingly, the high bleaching capacity of Na–bentonite was correlated with SiO_2 and Al_2O_3 contents in the range of 72.30–85.20% and 8.96–13.30% by weight, respectively. Moreover, the specific surface area and total pore volume of this activated clay also increased. In addition, after bleaching by Na–bentonite treated with 1.5 M H_2SO_4, the degummed palm oil appeared to be of good quality, leading to less deterioration and rancidity. Moreover, the bleached palm oil had lower yellowish colour, moisture content, and peroxide values than the degummed palm oil.

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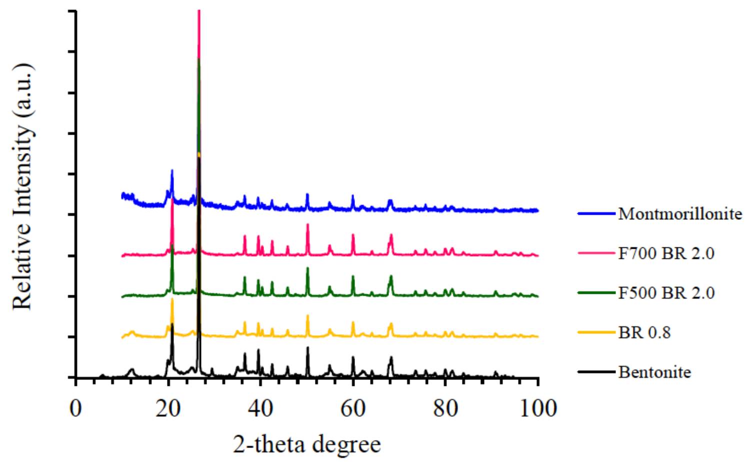
(a)



(b)

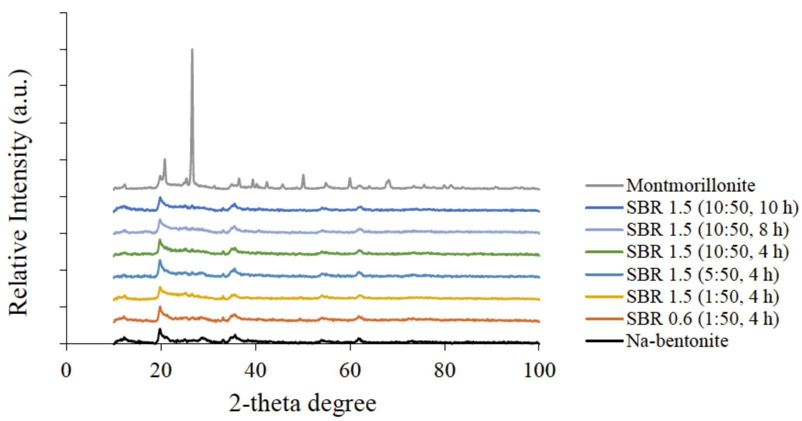


Figure 1. XRD patterns of (a) commercial clay, bentonite, and activated bentonites, and (b) Na-bentonite and activated Na-bentonites

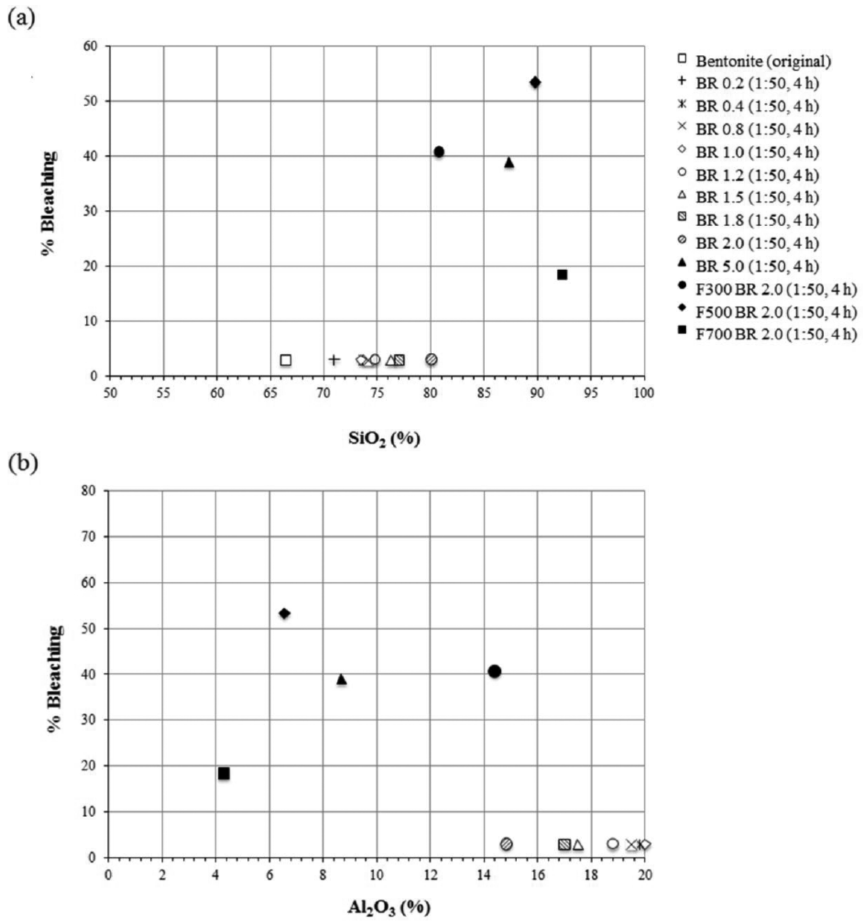


Figure 2. Relationship between % bleaching of palm oil and SiO_2 (a) Al_2O_3 (b) contents of activated bentonites.

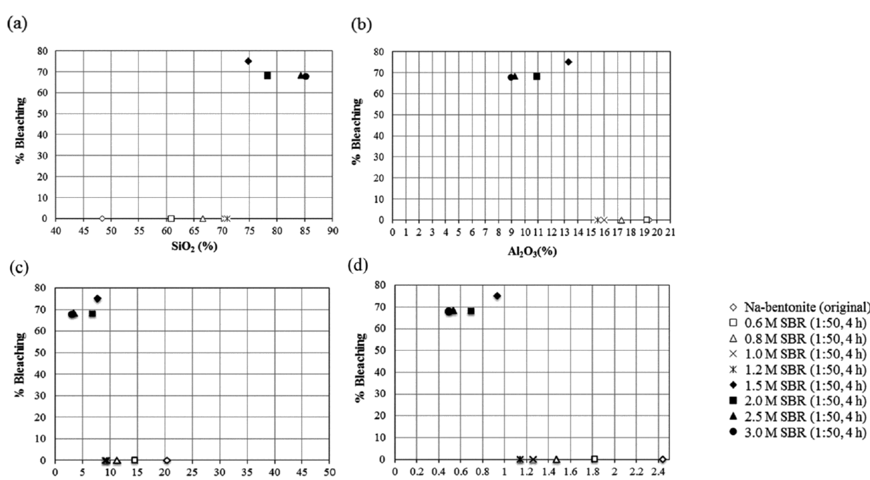


Figure 3. Relationship between % bleaching of palm oil and SiO_2 (a), Al_2O_3 (b), Fe_2O_3 (c) and MgO (d) contents of activated Na-bentonites.

Table 1. Chemical composition and bleaching capacity of commercial clay, bentonite and activated bentonites under various conditions.

Sample	Mass %								% Bleaching
	SiO_2	Al_2O_3	Fe_2O_3	CaO	TiO_2	K_2O	MgO	Na_2O	
Commercial clay	80.70	10.20	2.18	1.61	0.65	0.84	ND	ND	$67.09 \pm 0.50_e$
Bentonite (original)	66.40	20.30	7.65	1.98	1.38	1.16	0.48	0.20	0_a
BR 0.2	71.00	20.80	4.54	0.17	1.49	1.22	0.42	0.14	0_a
BR 0.4	73.70	19.80	2.75	0.16	1.53	1.26	0.42	0.13	0_a
BR 0.8	74.10	19.50	2.38	0.33	1.54	1.23	0.45	0.18	0_a
BR 1.0	73.50	20.00	2.57	0.29	1.54	1.25	0.45	0.17	0_a
BR 1.2	74.70	18.80	2.45	0.22	1.59	1.27	0.42	0.14	0_a
BR 1.5	76.30	17.50	2.28	0.22	1.63	1.26	0.39	0.14	0_a
BR 1.8	77.00	17.00	2.12	0.21	1.61	1.25	0.39	0.13	0_a
BR 2.0	80.00	14.80	1.59	0.18	1.58	1.15	0.33	0.15	0_a
BR 5.0	87.30	8.68	0.75	0.15	1.63	1.03	0.20	0.14	$38.95 \pm 2.11_c$
F300 BR 2.0	88.70	7.10	0.71	0.17	1.67	1.11	0.32	0.15	$40.70 \pm 4.75_c$
F500 BR 2.0	89.70	6.55	0.77	0.18	1.73	0.63	0.20	0.08	$53.33 \pm 3.04_d$
F700 BR 2.0	92.30	4.28	0.88	0.15	1.74	0.43	0.06	0.06	$18.47 \pm 1.39_b$

Note: BR 0.2, BR 0.4, BR 0.8, BR 1.0, BR 1.2, BR 1.5, BR 1.8, BR 2.0, BR 5.0 = refluxing bentonite with H_2SO_4 solution with 0.2–5.0 M at 90 °C for 4 h and the ratio of clays to acid was 1:50 (w/v); F300 BR 2.0, F500 BR 2.0, and F700 BR 2.0 = bentonites preheated at 300 °C, 500 °C, and 700 °C for 1 hour in a muffle furnace prior to refluxing with 2.0 M H_2SO_4 at 90 °C for 4 h and the ratio of clays to acid was 1:50 (w/v). For % bleaching, data are presented as mean±SD of three replication. Different letters indicate significant difference among treatments at the 0.05 significant level based on Duncan's multiple range test.

Table 2. Chemical compositions and bleaching capacity of commercial clay, Na–bentonite and activated Na–bentonites under various conditions.

Sample	Mass (%)								% Bleaching
	SiO_2	Al_2O_3	Fe_2O_3	CaO	TiO_2	K_2O	MgO	Na_2O	
Commercial clay	80.70	10.20	2.18	1.61	0.65	0.84	ND	ND	$67.09 \pm 0.50_c$
Na-bentonite (original)	48.40	19.40	20.40	2.44	1.49	0.17	2.44	4.22	0_a
SBR 0.6 (1:50, 4 h)	60.90	19.20	14.50	1.01	1.99	0.14	1.82	ND	0_a
SBR 0.8 (1:50, 4 h)	66.60	17.30	11.30	0.60	2.13	0.13	1.47	ND	0_a
SBR 1.0 (1:50, 4 h)	70.60	16.00	9.17	0.41	2.14	0.12	1.26	ND	0_a
SBR 1.2 (1:50, 4 h)	71.00	15.50	9.40	0.36	2.18	0.12	1.14	ND	0_a
SBR 1.5 (1:50, 4 h)	74.80	13.30	7.79	0.46	2.27	0.11	0.93	ND	$75.09 \pm 0.44_e$
SBR 2.0 (1:50, 4 h)	78.30	10.90	6.75	0.69	2.26	0.10	0.69	ND	$68.21 \pm 1.45_c$
SBR 2.5 (1:50, 4 h)	84.30	9.23	3.48	0.27	1.89	0.08	0.53	ND	$68.32 \pm 0.66_c$
SBR 3.0 (1:50, 4 h)	85.20	8.96	3.06	0.22	1.81	0.08	0.49	ND	$67.86 \pm 1.47_b$
SBR 1.5 (5:50, 4 h)	75.50	12.90	7.29	0.41	2.27	0.12	0.58	ND	$72.11 \pm 0.38_d$
SBR 1.5 (10:50, 4 h)	76.80	12.10	7.2	0.47	2.06	0.11	0.45	ND	$62.77 \pm 1.16_b$
SBR 1.5 (10:50, 6 h)	76.10	12.50	7.9	0.45	2.21	0.12	0.42	ND	$66.81 \pm 1.90_c$
SBR 1.5 (10:50, 8 h)	72.30	15.20	8.3	0.58	2.2	0.1	0.43	ND	$78.04 \pm 0.34_f$
SBR 1.5 (10:50, 10 h)	75.10	13.10	7.3	0.53	2.15	0.1	0.39	ND	$72.70 \pm 0.58_d$

Note: SBR 0.6 (1:50, 4 h), SBR 0.8 (1:50, 4 h), SBR 1.0 (1:50, 4 h), SBR 1.2 (1:50, 4 h), SBR 1.5 (1:50, 4 h), SBR 2.0 (1:50, 4 h), SBR 2.5 (1:50, 4 h), SBR 3.0 (1:50, 4 h) = refluxing Na–bentonite with H_2SO_4 solution with 0.6–3.0 M at 90 °C for 4 h and the ratio of clays to acid was 1:50 (w/v). SBR 1.5 (5:50, 4 h), SBR 1.5 (10:50, 4 h), SBR 1.5 (10:50, 6 h), SBR 1.5 (10:50, 8 h), and SBR 1.5 (10:50, 10 h) = refluxing Na–bentonite with 1.5 M H_2SO_4 concentration at 90 °C for 4 h-10 h and the ratio of clays to acid was 5:50 (w/v) and 10:50 (w/v), respectively. For % bleaching, data are presented as mean±SD of three replication. Different letters indicate significant difference among treatments at the 0.05 significant level based on Duncan's multiple range test.

Table 3. Specific surface area, total pore volume, micro pore volume and average pore size of commercial clay and activated Na–bentonites.

Sample names	Specific surface area (m_2/g)	Total pore volume (cc/g)	Micro pore volume (cc/g)	Average pore size (Å)
Commercial clay	160.90	0.32	0.09	80.47
Bentonite	42.30	0.1010	0.0341	37.74
Na-bentonite	67.47	0.1256	0.0052	30.22
SBR 1.5 (1:50, 4 h)	340.50	0.4465	0.2642	48.08
SBR 1.5 (5:50, 4 h)	303.90	0.3780	0.2184	46..80
SBR 1.5 (10:50, 4 h)	270.40	0.3164	0.1849	43.41
SBR 1.5 (10:50, 8 h)	373.20	0.4672	0.2862	52.06
SBR 1.5 (10:50, 10 h)	308.40	0.4150	0.2247	46.91

Note: SBR 1.5 (1:50, 4 h), SBR 1.5 (5:50, 4 h) and SBR 1.5 (10:50, 4 h) = refluxing Na–bentonite with 1.5 M H_2SO_4 concentration at 90 °C for 4 h and the ratio of clays to acid was 1:50 (w/v), 5:50 (w/v) and 10:50 (w/v), respectively.