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Synthesis and Properties of Zinc Aluminate Catalyst

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Recently, the growing interest in $ZnAl_2O_4$ li ti t l t t l t i h . i lmi t highh mo l t ilit , highmo h i l i t , i t t t tit t h mo t iti l t l t i i t li ti . i lmi t h ti- it i h h i mo h l i h l ti , - i ll i mo i ti ih 1 5 . th h t ti t l ti h h i i t 6 l h ti t mo g- t l mo l il li h ti l h l 7 . ti ti i h g ti l- 8 , i mo i ti l h 9 i h mo h l ti h l 10 .

The purpose of this study was to characterize the $ZnAl_2O_4$ i l t i i h- h mo l t mi it ti it i ti t mo ti h mo l $_{6\ 8}$ l h l . D h ti S h g ti l h l t l t h t i mo h . mo h mo t t mo t h ti , i g ih l i h 11 14 , h h h mo il h g t- ig t 15 20 . A h h t mo ti l h l l t h- ti h t h h t i ti h t l t mo t t t it i- ti . hi t ti mo l l h l i i ti i lmi t .

The catalyst used for this study was prepared as follows: predetermined amounts of aluminium and zinc nitrates were dissolved in 2.5 dm^3 i till t t mo tmo t . l j t t 8.8 ig , ih ti igh i mo t mo i l ti (25 t.%) t h it t l ti . h mi t ti 25mi . h i it t mo ilt h l tmo ih i till t . h t t , 4 mo^3 t th i h t i l h t i t l ih t t t ti 0.1 ig 3h . A t ligh t l i t t mo tmo t , h t i t t h l t t h ll ig ti th l t tmo t . h ltigg l t , i i l i t 873 4h . h t i t l t h i t h 0.6 1.2mo ti l . - i ti tt t i ih D -3 i tmo t ih i- ilt i ti . h t t mo tmo t mo 10 t 80 (2)

ith t 0.05 / S . h l tti me t l l t igh l t itti g g m S 21 . h mei ti th t l t i t igh AB -500t mei i l t mei ith l- ti ltg 90 . h ii ith i iti ti t mei B ti ith D lhime - hme h , ti l , h it g tS th tme t S liSi - it g t l lme t i , igh tme ti 1900 t . h i it , *i.e.* h t ti i B t t h th t l t, - t lih igh t Sh i i h me l l i - ih i i 22 . i it Al_2O_4 t mei me ti $_2$ 23 25 . i i ti t lih i th tme t - g me i ti (D) $_2$ t me tme - t . h D me ig h me me l t , t ll me t . h 100mg me l t t i h lime (30mlh/mei) t 773 0.5h t $_2$ l 10mei t me tme t . l $_2$ me ig h lime h me l t me tme t t th th tme t i t 773 th t 10 /mei . h $_2$S t ti i h l t me ig h i me me me it 200 - lme t me t .

The reactions of the transformation of the normal C_6–C_8 l h l i t ig t i l i l me h i i l ti- ll h t ti l t t ith i imet 8me . A t ll l t h me l ll th tme t me me t l g th t l t . 3 me^3 t l t . h th l h l t i lii ti- S l meh t h t mei me ith h li ih l l it = 3.0 / $_t$.h (l 1.0h^{-1}). me t i t ti l ti i ig tme t . A t h t ti ili ime h t i - l t tme t , h me t i t *ca* 2h . h l l t l g h me tg h . h h me tg h 6890 i l ith D t t l me -5 (30me 0.32me ill ith h hme h l ili). lime l i g .

The X-ray powder diffraction patterns of the hydrothermally synthesized $ZnAl_2O_4$ me l , ll ig h tme t t me t, h i ig 1. h D tt me l l i t t 873 (ig. 1A) me t t l , i i- tig high me l i i l ime th me ti h i Al_2O_4 phase. h h t t . h i ti h i lmei t t- l t me me i t t h tme t t me t, g ig ti l i th me l . h me l l i t t 1273 h D tt (ig. 1B) h igl - h i i l t t ith l tti t t l i lmei t . tlli Al_2O_4 h g t llit i , me - ig l i h (311) l ti , i t 30 me . h me h l- g h h h me ll t i i lmei t me l i t 413 , i , i t i ig 2, ligh t th t i Al_2O_4 i me-

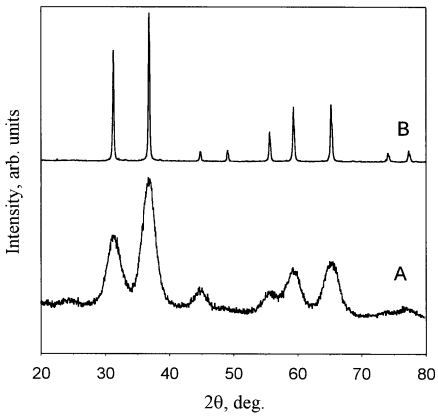

Figure 1. X-ray diffraction patterns of $ZnAl_{2}{}_{4}$ t l t t tm t t m t t 873 (A) and at 1423 K (B).

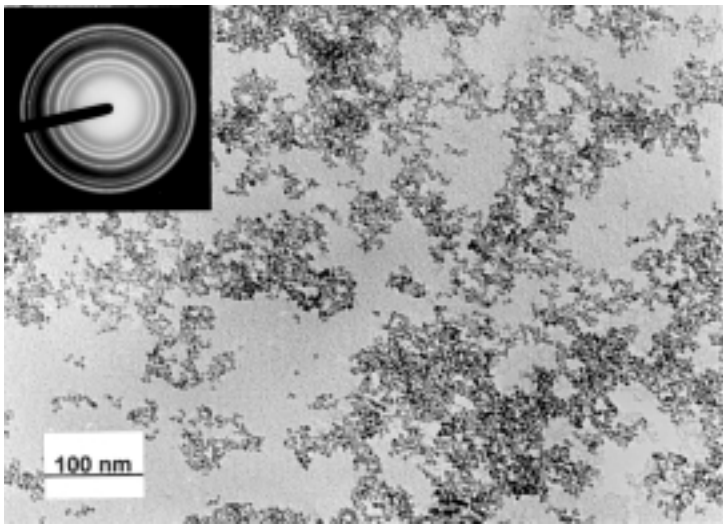

Figure 2. TEM micrograph of hydrothermally synthesized zinc aluminate sample dried at 413 K with SAD pattern showing rings those match d-spacings for the spinel structure of $ZnAl_{2}{}_{4}$.

i- h i l ti 5 m i h t h m S i - . t l t h t h g l t i (AD) tt i tt i t t h i l t t i lm i t . Dim t ti l $Al_{2}{}_{4}$,h t t 873 , i t t 7 m . h ti i lm i t t l t i i i l 1. h m t h l l ith h li h li 9,10,26 i g t m l t i m h . A ti i i $_{2}$ h h t th m l h i- t l t.

Table 1. Properties of zinc aluminate catalyst after calcination at 873 K for 4 h.

Phase composition	$ZnAl_2O_4$
tti t t Al_2O_4 (h t t 1423),	8.0928 (0.0005)
Average crystallite size, nm	7
i i , m^2/g	93
t l lm (t / $_0$ = 0.95), m^3/g	0.14
Mean pore radius r , m	2.8
i - i it t ti , m l /g	195
B t - i it t ti , m l /g	0
B i it , m l $_2$/g	180

ig 3 h t ti ti ti i h m $_2$ t 77 i iti ti Al_2O_4 li t t 873 . it g ti t t ih h i m t i l i i h m t ih l h t i l , i t 2 i h A l i i ti 27 , h i h gg t h m . h i t h t i l i h t i ti li i ti g ti l l li i l h l m gg g t gg l m t h i l ti- l . , h h t i l gg t h t h i m i h . h i iti ti l i h i t 1 4 m ih m m m t t t 2.8 m . B h i i g , it - l h t h m t i l t i i m m i ti l .

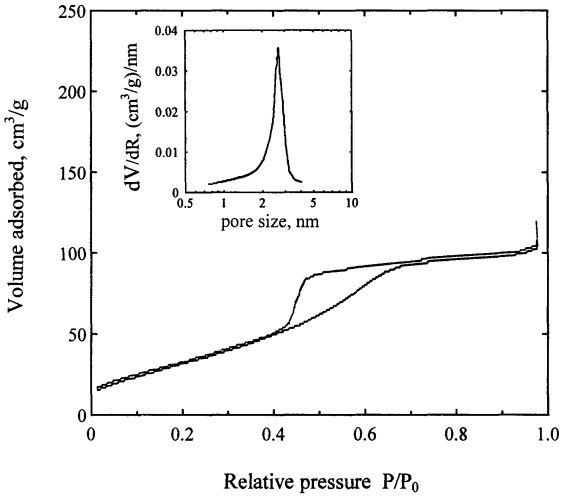

Figure 3. Nitrogen adsorption isotherm collected at 77 K and pore size distribution for $ZnAl_2O_4$ t l t. / $_0$ i l ti , h i h ili im h dsorbate and P_0 it t - ti t h t t m t ; h lm i t . t: i i - t i ti h D lim - lm h i ih respect to the pore diameter of the adsorbent].

Table lt rm l 6 8 l h l t rm ti i lmi t t l t.

Alcohol	Temperature K	Conversion %	Liquid products composition, %					
			alkene	aldehyde	ether	ester	ketone	Σ h
n-h l	573	21.1	traces	4.2	–	13.3	0.3	3.3
	603	37.2	0.7	9.9	–	23.7	0.7	2.2
	633	67.9	1.2	23.5	1.2	38.9	0.8	2.3
	663	92.3	2.4	34.6	5.8	37.1	2.6	9.8
	688	95.6	4.8	28.6	11.8	17.0	13.0	20.4
n-h t l	573	23.6	0.7	4.4	–	16.0	1.2	1.3
	608	49.0	1.4	14.1	traces	30.5	1.7	1.3
	638	77.7	4.5	34.9	0.6	33.0	2.3	2.4
	668	94.3	5.5	34.1	2.2	30.0	12.3	10.2
	698	97.1	12.0	23.9	10.0	2.2	25.7	23.3
n- t l	573	25.8	–	3.6	–	17.3	–	3.9
	608	45.9	1.9	10.3	–	26.9	traces	6.8
	638	67.6	2.8	27.4	0.5	30.5	0.4	6.0
	668	92.7	5.8	37.0	3.2	29.8	3.7	13.2
	693	97.2	10.4	28.0	7.5	5.9	12.3	33.1

Zinc aluminate, which was hydrothermally synthesised according to the applied procedure, showed both acidic and basic natures, thus it should exhibit both dehydration and dehydrogenation activities. Transformations of normal $C_{6\ 8}$ l h l t q i q h lt rm i q i l 2, h i h t h q q h i l h l t rm t q h i l q h rm i li i q q t. i l mi t h t ti i t rm ti rm l l h l. h ti t l t 573 698 . D i g h l h l i , q- t q h q g ti q q ti q i h ti q t. D h q g ti l q t q ti ig i i t rm t i t l q- h q : t 34.6% *n*-h l t 663 , 34.9% *n*-h t l t 638 q 37.0% *n*- t l t 668 *n*-h l, h t l q t l, ti l. h t t h t i q l q h q q t ti t q rm i l t . h q h q g ti h l h l rm i l it q h q ti t q i g l i q h . h ti it l h l $Al_{2\ 4}$ i q i t rm h t - q h i i q t l t, h i g i ti , h i h i g - li i h q h q g ti l h l 17 . h i gg t h t h t rm ti rm l l h l $Al_{2\ 4}$ t l t q q t g l it i q - ti . h ti t q i q i rm q h t h i l mi t t l t q rm t t h i q i q i ti .

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