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APPENDICES

Appendix A

Criteria for the selection of lead formulations

These two criteria were employed for the selection of lead formulations from IR reactor system for further testing.

Criteria1;

1. $T_{avg,2} - T_{avg,1} > 5$
2. $T_{avg,2} > T_{avg,1} + SD_1$ or else $SD_1 < SD_2$
3. $\Delta T_{avg} > SD_1 + SD_2$

Criteria 2;

1. $T_{avg,2} - T_{avg,1} > 5$
2. $T_{avg,2} > T_{avg,1} + SD_1$
3. $T_{avg,2} - SD_2 > T_{avg,1} + 0.5SD_1$

Where ΔT_{avg} = average different temperature

$T_{avg,1}$ = average temperature of each catalyst sample before reaction (under helium stream)

$T_{avg,2}$ = average temperature of each catalyst sample during reaction (under reactant stream)

SD_1 = standard deviation before reaction (under helium stream)

SD_2 = standard deviation during reaction (under reactant stream).

Appendix B

Table B1 Raw data obtained from IR reactor of all catalyst formulations

Catalyst	Ratio of metals on binary loading (%)				Before reaction		During reaction		ΔTavg
	Ni	La	Fe	Li	Tavg	SD_1	Tavg	SD_2	
C1	90	10	-	-	333.4	5.2	337.6	2.46	4.2
C2	80	20	-	-	362.0	4.6	366.0	1.73	4
C3	70	30	-	-	393.2	2.1	392.5	3.23	-0.7
C4	60	40	-	-	337.7	6.7	335.5	9.28	-2.2
C5	50	50	-	-	363.8	2.4	365.4	5.80	1.6
C6	40	60	-	-	289.6	4.9	293.0	4.86	3.4
C7	30	70	-	-	288.8	17.4	291.0	3.49	2.2
C8	20	80	-	-	319.1	23.8	313.5	7.75	-5.6
C9	10	90	-	-	309.9	5.7	331.2	5.60	21.3
C10	-	10	-	90	409.0	9.7	416.4	4.34	7.4
C11	-	20	-	80	377.1	5.0	378.8	3.12	1.7
C12	-	30	-	70	331.4	11.5	336.9	11.49	5.5
C13	-	40	-	60	409.0	9.1	408.5	9.83	-0.5
C14	-	50	-	50	381.3	4.1	380.2	2.40	-1.1
C15	-	60	-	40	303.9	15.4	296.8	8.80	-7.1
C16	-	70	-	30	315.6	7.5	360.0	20.93	44.4
C17	-	80	-	20	335.3	15.1	364.1	5.56	28.8
C18	-	90	-	10	299.4	5.4	301.2	6.78	1.8
C19	90	-	10	-	300.2	15.9	320.3	4.62	20.2
C20	80	-	20	-	351.0	1.0	349.2	2.67	-1.8
C21	70	-	30	-	379.8	1.7	415.6	9.87	35.8
C22	60	-	40	-	325.0	5.7	330.3	1.37	5.3
C23	50	-	50	-	361.2	1.6	360.9	1.11	-0.3
C24	40	-	60	-	334.1	10.5	342.3	8.64	8.2
C25	30	-	70	-	335.1	8.5	309.3	4.03	-25.8
C26	20	-	80	-	335.7	10.9	336.8	3.98	1.2
C27	10	-	90	-	319.3	7.5	319.5	3.86	0.3
C28	90	-	-	10	355.5	7.5	357.8	1.82	2.3

Table B1 Continued

Catalyst	Ratio of metals on binary loading (%)				Before reaction		During reaction		Tavg
	Ni	La	Fe	Li	Tavg	SD	Tavg	SD	
C31	60	-	-	40	299.7	8.0	300.5	2.25	0.8
C32	50	-	-	50	349.8	4.0	347.2	2.51	-2.7
C33	40	-	-	60	313.7	5.7	311.8	3.03	-1.9
C34	30	-	-	70	372.4	3.0	370.9	3.93	-1.5
C35	20	-	-	80	339.5	6.9	336.3	4.73	-3.2
C36	10	-	-	90	284.0	6.6	289.4	12.41	5.4
C37	-	-	10	90	300.4	2.5	303.0	1.15	2.6
C38	-	-	20	80	324.6	1.42	328.0	2.77	3.4
C39	-	-	30	70	319.8	3.31	329.8	5.30	10
C40	-	-	40	60	305.6	1.68	308.8	2.67	3.2
C41	-	-	50	50	332.4	0.80	336.0	1.53	3.6
C42	-	-	60	40	355.4	1.62	356.8	0.68	1.4
C43	-	-	70	30	301.8	3.76	308.4	2.92	6.6
C44	-	-	80	20	330.4	7.23	334.6	2.21	4.2
C45	-	-	90	10	358.0	1.26	361.6	2.13	3.6
C46	0	-	-	-	360.2	3.06	361.0	1.00	0.8
C47	0.1	-	-	-	342.2	4.35	341.6	2.13	-0.6
C48	1	-	-	-	298.6	3.56	299.2	4.84	0.6
C49	2	-	-	-	376.6	2.24	377.8	0.68	1.2
C50	3	-	-	-	349.2	2.32	349.6	1.59	0.4
C51	5	-	-	-	324.2	2.79	324.4	1.37	0.2
C52	7	-	-	-	369.6	2.15	366.6	1.69	-3
C53	9	-	-	-	341.4	0.49	346.0	1.53	4.6
C54	10	-	-	-	328.0	1.79	327.6	1.88	-0.4

Appendix C

The reaction of CO oxidation is shown as Reaction (2.1). Conversion of this reaction can be calculated;

$$\%CO\ conversion = \left[\frac{mole\ CO\ in - mole\ CO\ out}{mole\ CO\ in}\right] * 100$$

Table C1 Carbon monoxide conversion of lead formulations tested by conventional method

Catalyst	Ratio of metals on binary loading (%)				Carbon monoxide conversion (%)
	Ni	La	Fe	Li	
Support	-	-	-	-	67.86
C1	90	10	-	-	100.0
C3	70	30	-	-	100.0
C8	20	80	-	-	99.30
C16	-	70	-	30	6.84
C17	-	80	-	20	11.65
C18	-	90	-	10	11.54
C19	90	-	10	-	79.55
C20	80	-	20	-	24.74
C21	70	-	30	-	31.99
C23	50	-	50	-	7.53
C27	10	-	90	-	4.86
C39		-	40	60	13.33
C51	5	-	-	-	100.0

Table C2 Carbon monoxide conversion of La/Ni loaded catalyst with the La/Ni ratio of 1:9 at various temperature

Reaction temperature(°C)	Carbon monoxide conversion (%) of the catalyst with Ni:La=9:1
80	5.3
150	26.85
250	93.66
350	100

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