

**Table 1**Chemical composition of alkali promoted  $\text{Co}_4\text{MnAlO}_x$  mixed oxides determined from AAS, SEM/EDX and XPS

Catalyst	Alkali (wt. %)	Molar ratio Co:Mn:Al		Molar ratio M:Co <sup>b)</sup>		
		SEM/EDX	XPS	AAS	SEM/EDX	XPS
$\text{Co}_4\text{MnAlO}_x$	0.40 <sup>a)</sup>	4 : 1.1 : 1.5	4 : 1.0 : 2.0	0.022 <sup>a)</sup>	n.d.	n.d.
Li/ $\text{Co}_4\text{MnAlO}_x$	0.18	4 : 1.1 : 0.8	4 : 1.1 : 1.9	0.031	n.d.	0
Na/ $\text{Co}_4\text{MnAlO}_x$	1.15	4 : 1.0 : 1.5	4 : 1.1 : 1.9	0.060	0.178	0.195
K/ $\text{Co}_4\text{MnAlO}_x$	1.12	4 : 0.9 : 2.0	4 : 1.2 : 2.0	0.034	0.046	0.106
Rb/ $\text{Co}_4\text{MnAlO}_x$	2.93	4 : 1.1 : 1.0	4 : 1.3 : 1.9	0.041	0.051	0.103
Rb/ $\text{Co}_4\text{MnAlO}_x^*$	n.d.	n.d.	4 : 1.3 : 1.9	n.d.	n.d.	0.101
Cs/ $\text{Co}_4\text{MnAlO}_x$	3.40	4 : 1.0 : 3.1	4 : 1.3 : 1.9	0.031	0.041	0.203
Cs/ $\text{Co}_4\text{MnAlO}_x^*$	n.d.	n.d.	4 : 0.9 : 1.5	n.d.	n.d.	0.203

\* Catalyst after the laboratory  $\text{N}_2\text{O}$  catalytic decomposition experiments<sup>a)</sup> Residual Na from coprecipitation procedure<sup>b)</sup> M – alkali metal

**Table 2**Specific surface area, calculated crystallite size ( $L_c$ ) and experimental lattice d-spacing values (311) of alkali promoted  $\text{Co}_4\text{MnAlO}_x$  mixed oxides

Catalyst	$S_{\text{BET}}$ ( $\text{m}^2 \text{g}^{-1}$ )	$L_c$ (nm)	$d_{311}$ (nm)
$\text{Co}_4\text{MnAlO}_x$	98	11.3	0.244
Li/ $\text{Co}_4\text{MnAlO}_x$	100	11.4	0.244
Na/ $\text{Co}_4\text{MnAlO}_x$	91	10.2	0.244
K/ $\text{Co}_4\text{MnAlO}_x$	96	10.3	0.246
Rb/ $\text{Co}_4\text{MnAlO}_x$	n.d.	10.7	0.246
Cs/ $\text{Co}_4\text{MnAlO}_x$	84	12.2	0.244

**Table 3**  
Binding energies of core level electrons of catalysts

Catalyst	M <sup>(a)</sup>	Co 2p <sub>3/2</sub>		Co 2p <sub>3/2-1/2</sub> <sup>(b)</sup>	Co <sup>2+</sup> /Co <sup>3+</sup> <sup>(c)</sup>	Mn 2p <sub>3/2</sub>		O 1s		Mn 2p <sub>3/2</sub> - O 1s <sup>(d)</sup>	Al 2p	
Co <sub>4</sub> MnAlO <sub>x</sub>	-	780.0	781.7	15.3	2.34	641.3	643.0	529.8	531.5		111.5	73.2
Li/ Co <sub>4</sub> MnAlO <sub>x</sub>	-	779.6	781.3	15.2	1.18	641.0	642.7	529.6	531.3		111.6	73.1
Na/ Co <sub>4</sub> MnAlO <sub>x</sub>	1071.3	779.7	781.2	15.2	1.01	641.0	642.7	529.6	531.0	533.8	111.7	73.0
K/ Co <sub>4</sub> MnAlO <sub>x</sub>	292.7 295.4	779.7	781.3	15.3	0.97	641.0	642.9	529.6	531.0	533.6	112.0	73.0
Rb/ Co <sub>4</sub> MnAlO <sub>x</sub>	109.4 110.9	779.4	781.0	15.4	1.47	640.7	642.6	529.3	530.7	533.8	111.8	72.7
Rb/ Co <sub>4</sub> MnAlO <sub>x</sub> *	109.8 111.3	779.8	781.3	15.4	1.15	641.1	642.5	529.7	531.4		111.4	73.1
Cs/ Co <sub>4</sub> MnAlO <sub>x</sub>	724.1 738.1	779.5	781.0	15.3	1.13	640.9	642.5	529.4	531.9		112.0	72.6
Cs/ Co <sub>4</sub> MnAlO <sub>x</sub> *	724.3 738.3	779.8	781.3	15.3	1.14	641.1	642.6	529.7	531.0		112.1	73.1

\* Catalyst after laboratory N<sub>2</sub>O catalytic decomposition experiments

<sup>(a)</sup> M - alkali metals: Na 1s, K 2p<sub>3/2</sub>, 2p<sub>1/2</sub>, Rb 3d<sub>3/2</sub>, 3d<sub>5/2</sub>, Cs 3d<sub>3/2</sub>, 3d<sub>5/2</sub>

<sup>(b)</sup> Co 2p<sub>3/2-1/2</sub> effective spin-orbit splitting

<sup>(c)</sup> Surface molar ratio

<sup>(d)</sup> O 1s (component with the lowest BE) to Mn 2p<sub>3/2</sub> peak separation

**Table 4**CO<sub>2</sub>-TPD, NH<sub>3</sub>-TPD and H<sub>2</sub>-TPR of alkali promoted Co<sub>4</sub>MnAlO<sub>x</sub> mixed oxide

Catalyst	NH <sub>3</sub> -TPD mmol NH <sub>3</sub> /g 25-500°C	CO <sub>2</sub> -TPD mmol CO <sub>2</sub> /g 25-500°C	H <sub>2</sub> -TPR (mmol/g) 25-1000 °C	T <sub>max</sub> <sup>b</sup> (°C)
Co <sub>4</sub> MnAlO <sub>x</sub>	0.50	0.16	14.04 <sup>a</sup>	391; 775
Li/ Co <sub>4</sub> MnAlO <sub>x</sub>	0.25	0.34	12.79	399; 741
Na/ Co <sub>4</sub> MnAlO <sub>x</sub>	0.13	0.45	10.60	417; 758
K/ Co <sub>4</sub> MnAlO <sub>x</sub>	0.16	0.47	9.22	413; 761
Rb/ Co <sub>4</sub> MnAlO <sub>x</sub>	0.06	0.48	9.78	407; 767
Cs/ Co <sub>4</sub> MnAlO <sub>x</sub>	0.01	0.53	11.52	403; 767

<sup>a</sup> 25-900 °C<sup>b</sup> Temperature maxima of reduction peaks from H<sub>2</sub>-TPR