Catalysts for Reforming, Power to Liquids (PtL), Ammonia and Power to X pathways

sbh4 consulting

Process	Reaction	Enthalpy of reaction	Tempera-ture / °C	Typical catalysts	Commercial catalyst examples
Steam methane reforming (SMR)	$CH_4 + H_2O \rightarrow CO + 3H_2$	206 kJ/mol	700–950	NiO-based	Clariant REFORMAX 330 LDP
Oxygen-fed partial oxidation (POx)	$2CH_4 + O_2 \rightarrow 2CO + 4H_2$	– 24.5 kJ/mol	700–1100	CaAl12O19	Clariant REFORMAX 420 with REFORMAX 330 LDP
High-temperature Water Gas Shift (HT WGS)	$CO + H_2O \rightarrow CO_2 + H_2$	– 131.2 kJ/mol	320–450	Fe_2O_3/Cr_2O_3 with Cu promoter	Johnson Matthey KATALCO 71 range, Clariant ShiftMax 120
Low-temperature Water Gas Shift (LT WGS)	$CO + H_2O \rightarrow CO_2 + H_2$	– 131.2 kJ/mol	180–270	CuO & ZnO on alumina	Johnson Matthey KATALCO 83 range, Clariant ShiftMax 217
Reverse Water Gas Shift (rWGS)	$CO_2 + H_2 \rightarrow CO + H_2O$	41.5 kJ/mol	700–900	Ni-based	Clariant HyProGen R-70
Catalytic POx rWGS	$2CO_2 + 2O_2 + 6H_2 \rightarrow 2CO + 6H_2O$	$\Delta H < 0$	800–950	Ni on metal oxide, Rh on alumina	Johnson Matthey HyCOgen, VTT
Dry Methane Reforming (DMR)	$CO_2 + CH_4 \rightarrow 2CO + 2H_2$	247.1 kJ/mol	800–950	Ni oxides	BASF SYNSPIRE G1-110, Clariant HyProGen R-70
Methanation of CO_2	$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$	– 165.0 kJ/mol	300–400	NiO/alumina	Clariant METH 135, Topsøe MCR-2
Methanol Synthesis from Syngas	$CO + 2H_2 \rightarrow CH_3OH$	– 90.4 kJ/mol	200–300	CuO/ZnO/MgO on alumina	Topsøe MK-121, Johnson Matthey KATALCO 51, Clariant MegaMax 900
Methanol Synthesis via CO_2-Hydrogenation	$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$	– 49.5 kJ/mol	200–300	Cu-based	Johnson Matthey eMERALD, Clariant MegaMax800
Methanol to Olefins (ethylene)	$2CH_3OH \rightarrow C_2H_4 + 2H_2O$	– 11.72 kJ/mol	400–500	SAPO-34, ZSM-5	UOP MTO-600
Methanol to Olefins (propylene)	$3CH_3OH \rightarrow C_3H_6 + 3H_2O$	– 30.98 kJ/mol	400–500	SAPO-34, ZSM-22	Clariant MTPROP
Methanol reforming to syngas	$CH_3OH + H_2O \rightarrow 3H_2 + CO_2$	49,2 kJ/mol	240–320	CuO/ZnO/MgO on alumina	Topsøe MDK-20
DME Synthesis from methanol	$2CH_3OH \rightarrow CH_3OCH_3 + H_2O$	– 23.5 kJ/mol	250–300	$Al2O_3$ or zeolite based	Topsøe DME-99-ECO
DME to Paraffins	$CH_3OCH_3 \rightarrow 2(–CH_2–) + H_2O$	$\Delta H < 0$	320–380	Zeolite based, with iron promoter	Nanostructured ZSM-5
Formic Acid Synthesis via CO_2-Hydrogenation	$CO_2 + H_2 \rightarrow HCOOH$	– 31.2 kJ/mol	<100	RuCl2(PTA)4, CU-MOF-5	Emerging
CO-Based Fischer-Tropsch Synthesis (CO FTS)	$CO + 2H_2 \rightarrow (–CH_2-) + H_2O$	– 152 kJ/mol	180–250	Co-, Fe-based	Johnson Matthey FT CANS, Greyrock GreyCat
CO_2-Based Fischer-Tropsch Synthesis (CO_2 FTS)	$CO_2 + 3H_2 \rightarrow (–CH_2–) + 2H_2O$	– 111 kJ/mol	300–350	Na or K modified Co-Fe based	Emerging
Ammonia synthesis (Haber Bosch)	$N_2 + 3H_2 \rightarrow 2NH_3$	– 45,9 kJ/mol NH_3	350–550	Fe-based	Topsøe KM1
Low temperature ammonia cracking	$2NH_3 \rightarrow N_2 + 3H_2$	45,9 kJ/mol NH_3	400–500	Ru, PGM-based	Johnson Matthey KATALCO 27-612, Clariant HyProGen 850 DCARB
High temperature ammonia cracking	$2NH_3 \rightarrow N_2 + 3H_2$	45,9 kJ/mol NH_3	600–800	Ni-based	Johnson Matthey KATALCO 27-2, Topsøe H_2Retake, Clariant HyProGen 820 DCARB
PEM electrolyser cathode reaction (HER)	$4H^+ + 4e– \rightarrow 2H_2$	285.83 kJ/mol water	50–80	Pt	Pajarito Powder Pt/ECS, Johnson Matthey Platinum black HSA
PEM electrolyser anode reaction (OER)	$2H_2O \rightarrow 4H^+ + 4e– + O_2$	285.83 kJ/mol water	50–80	Ir	Pajarito Powder EEC-IrOx, Johnson Matthey Iridium-black
PEM fuel cell cathode reaction	$4H^+ + 4e– + O_2 \rightarrow 2H_2O$	– 285.83 kJ/mol water	ambient–55	Pt-based	Pajarito Powder Pt/ECS-3701, Heraeus H_2FC-50Pt-C700
PEM fuel cell anode reaction	$H_2 \rightarrow 2H^+ + 2e–$	– 285.83 kJ/mol water	ambient–55	Pt	Pajarito Powder Pt/ECS, Heraeus H_2FC-30Pt-C60T
AEM electrolyser cathode reaction (HER)	$2H_2O + 2e– \rightarrow 2OH^- + H_2$	285.83 kJ/mol water	ambient–55	non-PGM	Pajarito Powder Pt/ECS
AEM electrolyser anode reaction (OER)	$4OH^- \rightarrow 2H_2O + O_2 + 4e–$	285.83 kJ/mol water	ambient–55	Ni, Co, Fe-based	Pajarito Powder EEC-PbRuOx