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AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,  
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,  
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,  
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,  
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(54) Title: SYNERGIZED PGM CATALYST SYSTEMS INCLUDING RHODIUM FOR TWC APPLICATION

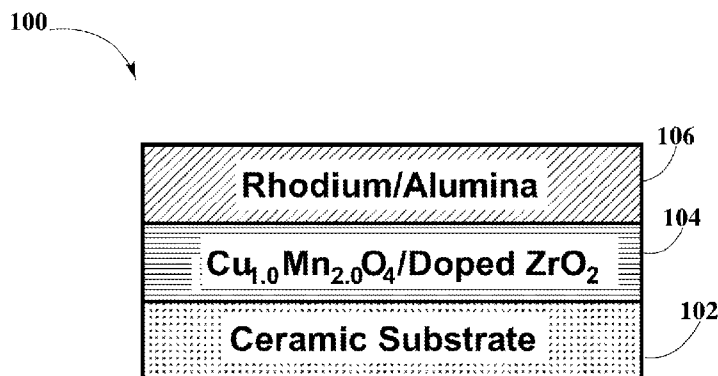


FIG. 1

(57) Abstract: Synergized Platinum Group Metals (SPGM) catalyst system for TWC application is disclosed. Disclosed SPGM catalyst system may include a washcoat that includes Cu-Mn spinel structure, supported on doped ZrO<sub>2</sub>, and an overcoat that includes PGM, such as Rhodium (Rh) supported on carrier material oxides, such as alumina. SPGM catalyst system shows significant improvement in nitrogen oxide reduction performance under lean and also rich operating conditions. Furthermore, disclosed SPGM catalyst systems are found to have enhanced fresh and aged catalytic activity compared to PGM catalyst system, showing that there is a synergistic effect between PGM catalyst, such as Rh, and Cu-Mn spinel within disclosed SPGM catalyst system, which help in activity and thermal stability of disclosed SPGM catalyst.



INTERNATIONAL SEARCH REPORT

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**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC(8) - B01J 23/40; B01J 23/72; B01J 23/34; B01D 53/94 (2016.01)  
 CPC - Y02T 10/22; B01J 23/005; B01J 23/46; B01J 23/34; B01J 23/656; B01D 53/9468; B01D 53/9445  
 According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**  
 Minimum documentation searched (classification system followed by classification symbols)  
 IPC(8) - B01J 23/40; B01J 23/72; B01J 23/34; B01D53/94 (2016.01)  
 CPC - Y02T 10/22; B01J 23/005; B01J 23/46; B01J 23/34; B01J 23/656; B01D 53/9468; B01D 53/9445

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
 Patents and non-patent literature (classification, keyword; search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 PatBase, Google Scholar (NPL), Google Patents; search terms: synergized platinum group metal catalyst, overcoat, washcoat, substrate, ceramic, foam, metallic, honeycomb, rhodium, carrier oxide, aluminum oxide, Cu-Mn spinel, CuMn2O4, support oxide, doped ZrO2, Niobium-zirconia, g/ft3, aged, hydrothermal, fuel cut, NOx, CO, HC, exhaust, engine

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 8,845,987 B1 (NAZARPOOR et al.) 30 September 2014 (30.09.2014) col 1, ln 21-29, 66-67; col 2, ln 1-9, 21-22, 42-53; col 3, ln 47-50, 53-54, 65-67; col 4, ln 1-2, 4--8, 10-20, 28-43; col 5, ln 27-28, 30-33, 46-49, 55-67; col 6, ln 1-4, 22-25, 35-38, 50-62; col 7, ln 11-16; claim 1; Fig. 2-4	1-11, 14-36, 39-45 ----- 12-13, 37-38
Y	US 2014/0271387 A1 (NAZARPOOR) 18 September 2014 (18.09.2014) para [0003], [0005]-[0006], [0010]-[0011], [0017], [0043], [0046]-[0047], [0049]-[0051], [0079], [0082], [0089]	12-13, 37-38
A	US 4,188,309 A (VOLKER et al.) 12 February 1980 (12.02.1980) entire document, especially col 4, ln 1-4; col 6, ln 32-43, 46-50; col 8, ln 6-14, 19-21, 29-32, 39-59	19, 44
A	US 4,367,162 A (FUJITANI et al.) 04 January 1983 (04.01.1983) col 1, ln 8-11, 16-28	19, 44
A	US 2014/0274674 A1 (NAZARPOOR et al.) 18 September 2014 (18.09.2014) entire document, especially para [0003], [0010], [0044]-[0049], [0052]	9, 34
A	US 6,375,910 B1 (DEEBA et al.) 23 April 2002 (23.04.2002) entire document, especially col 1, ln 20-26; col 3, ln 50-52; col 5, ln 13-14; col 8, ln 6-8	9, 34

Further documents are listed in the continuation of Box C.

\* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

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