

# in situ XAFS法による カーバイド触媒生成過程の解析

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## 触媒開発

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|                       |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                  |                  |                   |                   |  |  |  |  |
|-----------------------|--------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|------------------|------------------|-------------------|-------------------|--|--|--|--|
| alkali metals         |                    |                     |                     |                     |                     |                     |                     |                     |                     | noble gases         |                     |                     |                     |                     |                     |                     |                     |                  |                  |                   |                   |  |  |  |  |
| 1<br>H<br>1.01        |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                  | 2<br>He<br>4.00  |                   |                   |  |  |  |  |
| 3<br>Li<br>6.94       | 4<br>Be<br>9.01    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     | 5<br>B<br>10.81     | 6<br>C<br>12.01     | 7<br>N<br>14.01  | 8<br>O<br>16.00  | 9<br>F<br>18.99   | 10<br>Ne<br>20.18 |  |  |  |  |
| alkaline earth metals |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                  |                  | non metals        |                   |  |  |  |  |
| 11<br>Na<br>22.99     | 12<br>Mg<br>24.31  |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     | 13<br>Al<br>26.98   | 14<br>Si<br>28.09   | 15<br>P<br>30.97 | 16<br>S<br>32.06 | 17<br>Cl<br>35.45 | 18<br>Ar<br>39.95 |  |  |  |  |
|                       |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     | other metals        |                     |                  |                  |                   |                   |  |  |  |  |
| 19<br>K<br>39.10      | 20<br>Ca<br>40.08  | 21<br>Sc<br>44.96   | 22<br>Ti<br>47.88   | 23<br>V<br>50.94    | 24<br>Cr<br>51.996  | 25<br>Mn<br>54.94   | 26<br>Fe<br>55.85   | 27<br>Co<br>58.93   | 28<br>Ni<br>58.70   | 29<br>Cu<br>63.55   | 30<br>Zn<br>65.37   | 31<br>Ga<br>69.72   | 32<br>Ge<br>72.64   | 33<br>As<br>74.92   | 34<br>Se<br>78.96   | 35<br>Br<br>79.90   | 36<br>Kr<br>83.80   |                  |                  |                   |                   |  |  |  |  |
| Potassium             | Calcium            | Scandium            | Titanium            | Vanadium            | Chromium            | Manganese           | Iron                | Cobalt              | Nickel              | Copper              | Zinc                | Gallium             | Germanium           | Arsenic             | Selenium            | Bromine             | Krypton             |                  |                  |                   |                   |  |  |  |  |
| 37<br>Rb<br>85.47     | 38<br>Sr<br>87.62  | 39<br>Y<br>88.91    | 40<br>Zr<br>91.22   | 41<br>Nb<br>92.91   | 42<br>Mo<br>95.94   | 43<br>Tc<br>98.906  | 44<br>Ru<br>101.07  | 45<br>Rh<br>102.91  | 46<br>Pd<br>106.42  | 47<br>Ag<br>107.87  | 48<br>Cd<br>112.41  | 49<br>In<br>114.82  | 50<br>Sn<br>118.71  | 51<br>Sb<br>121.76  | 52<br>Te<br>127.60  | 53<br>I<br>126.90   | 54<br>Xe<br>131.30  |                  |                  |                   |                   |  |  |  |  |
| Rubidium              | Strontium          | Yttrium             | Zirconium           | Niobium             | Molybdenum          | Technetium          | Ruthenium           | Rhodium             | Palladium           | Silver              | Cadmium             | Indium              | Tin                 | Antimony            | Tellurium           | Iodine              | Xenon               |                  |                  |                   |                   |  |  |  |  |
| 55<br>Cs<br>132.91    | 56<br>Ba<br>137.33 | 57<br>La<br>138.91  | 58<br>Ce<br>140.12  | 59<br>Pr<br>140.91  | 60<br>Nd<br>144.24  | 61<br>Pm<br>144.91  | 62<br>Sm<br>150.36  | 63<br>Eu<br>151.96  | 64<br>Gd<br>157.25  | 65<br>Tb<br>158.93  | 66<br>Dy<br>162.50  | 67<br>Ho<br>164.93  | 68<br>Er<br>167.26  | 69<br>Tm<br>168.93  | 70<br>Yb<br>173.05  | 71<br>Lu<br>174.97  | 72<br>Hf<br>178.49  |                  |                  |                   |                   |  |  |  |  |
| Cesium                | Barium             | Lanthanum           | Hafnium             | Tantalum            | Tungsten            | Rhenium             | Osmium              | Iridium             | Platinum            | Gold                | Mercury             | Thallium            | Lead                | Bismuth             | Polonium            | Astatine            | Radon               |                  |                  |                   |                   |  |  |  |  |
| 87<br>Fr<br>223.02    | 88<br>Ra<br>226.02 | 89<br>Ac<br>227.03  | 90<br>Th<br>232.04  | 91<br>Pa<br>231.04  | 92<br>U<br>238.03   | 93<br>Np<br>237.05  | 94<br>Pu<br>244.06  | 95<br>Am<br>243.06  | 96<br>Cm<br>247.07  | 97<br>Bk<br>247.07  | 98<br>Cf<br>251.08  | 99<br>Es<br>252.08  | 100<br>Fm<br>257.10 | 101<br>Md<br>258.10 | 102<br>No<br>259.10 | 103<br>Lr<br>262.10 | 104<br>Rf<br>261.10 |                  |                  |                   |                   |  |  |  |  |
| Lanthanum series      |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     | Actinide series  |                  |                   |                   |  |  |  |  |
| 0                     |                    | 102<br>Ce<br>140.12 | 103<br>Pr<br>140.91 | 104<br>Nd<br>144.24 | 105<br>Pm<br>144.91 | 106<br>Sm<br>150.36 | 107<br>Eu<br>151.96 | 108<br>Gd<br>157.25 | 109<br>Tb<br>158.93 | 110<br>Dy<br>162.50 | 111<br>Ho<br>164.93 | 112<br>Er<br>167.26 | 113<br>Tm<br>168.93 | 114<br>Yb<br>173.05 | 115<br>Lu<br>174.97 |                     |                     |                  |                  |                   |                   |  |  |  |  |
|                       |                    | Corium              | Praseodymium        | Nodymium            | Promethium          | Samarium            | Europium            | Gadolinium          | Terbium             | Dysprosium          | Holmium             | Erbium              | Thulium             | Ytterbium           | Lutetium            |                     |                     |                  |                  |                   |                   |  |  |  |  |
| への転換                  |                    | 90<br>Th<br>232.04  | 91<br>Pa<br>231.04  | 92<br>U<br>238.03   | 93<br>Np<br>237.05  | 94<br>Pu<br>244.06  | 95<br>Am<br>243.06  | 96<br>Cm<br>247.07  | 97<br>Bk<br>247.07  | 98<br>Cf<br>251.08  | 99<br>Es<br>252.08  | 100<br>Fm<br>257.10 | 101<br>Md<br>258.10 | 102<br>No<br>259.10 | 103<br>Lr<br>262.10 |                     |                     |                  |                  |                   |                   |  |  |  |  |
| Actinide series       |                    |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                     |                  |                  |                   |                   |  |  |  |  |
|                       |                    | Thorium             | Protactinium        | Uranium             | Neptunium           | Plutonium           | Americium           | Curium              | Berkelium           | Californium         | Einsteinium         | Fermium             | Mendelevium         | Nobelium            | Lavrencium          |                     |                     |                  |                  |                   |                   |  |  |  |  |

高機能化・  
カーバイド・ナイト  
ライドへの転換

高機能触媒材料  
高価・希少  
代替材料が必要