

# 研究室紹介

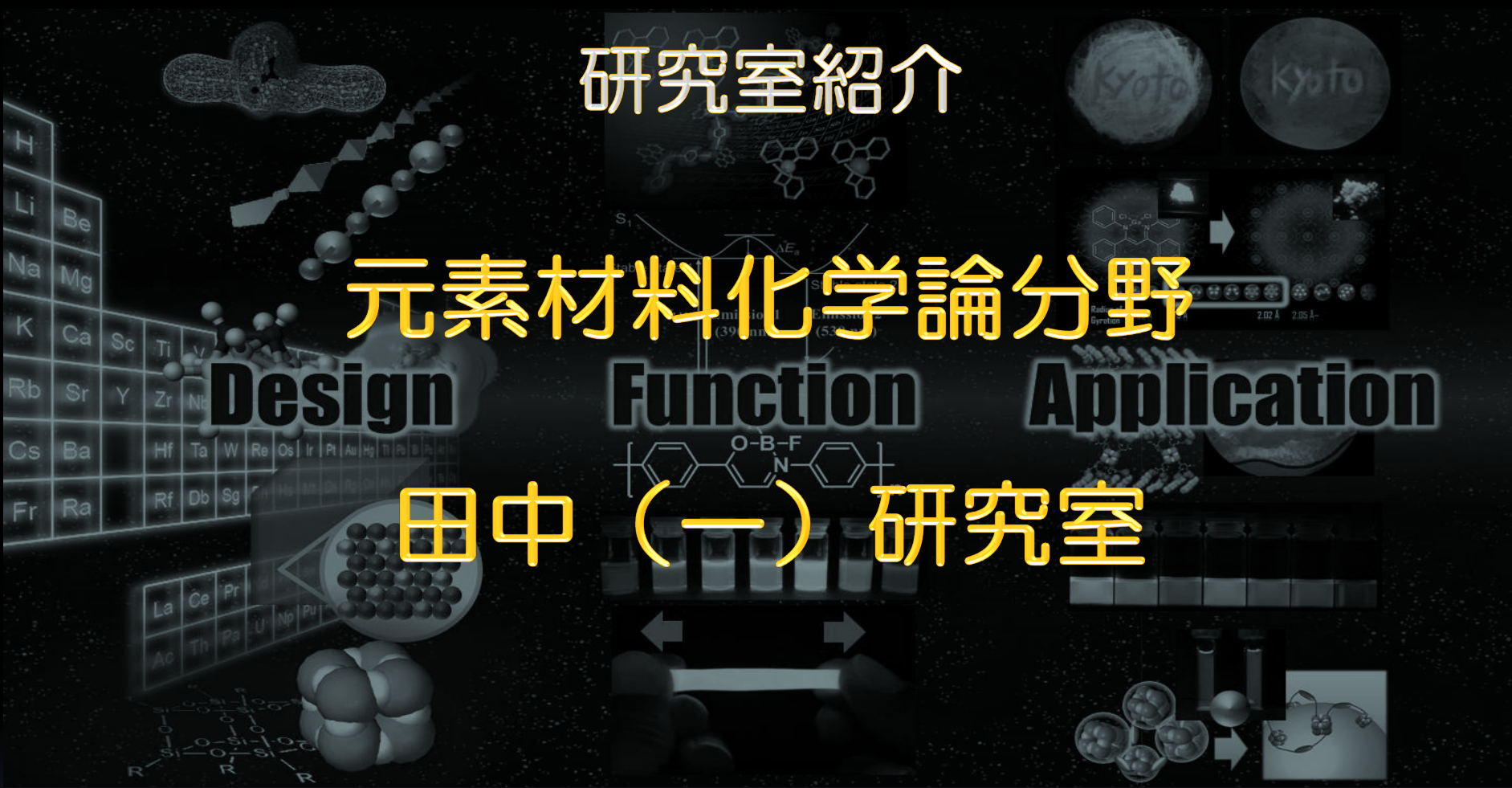
## 元素材料化学論分野

**Design**

**Function**

**Application**

田中（一）研究室



# 桂キャンパス



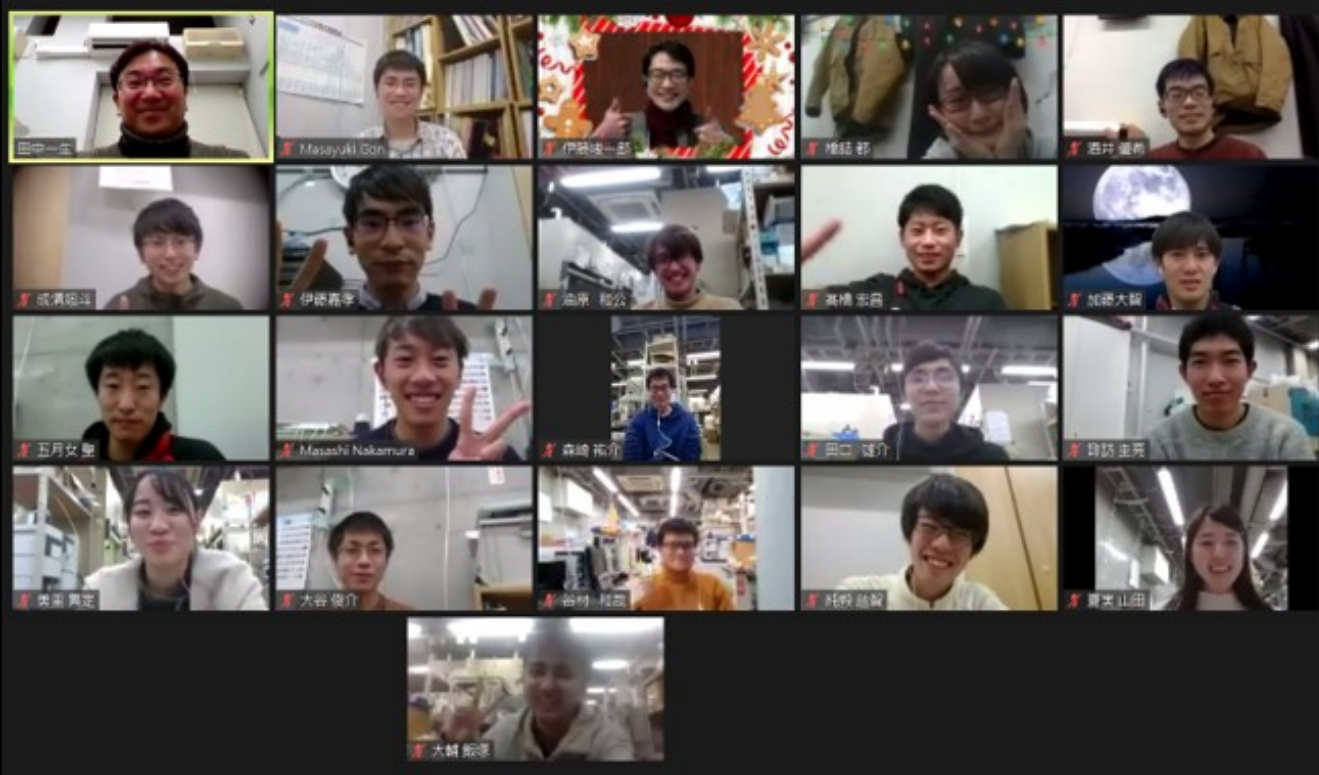
コロナ前



自粛中



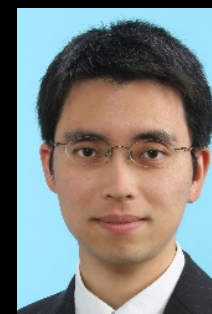
# 研究室メンバー



博士：2名  
修士：10名  
B4：5名



田中 一生 教授

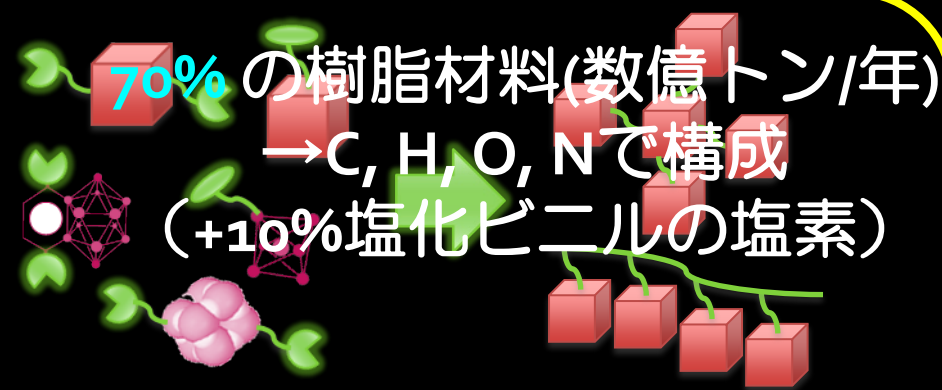


権 正行 助教



伊藤峻一郎 助教

# 研究目標：「元素材料」の創出



機能の最小単位  
=「元素ブロック」

機能性  
高分子材料

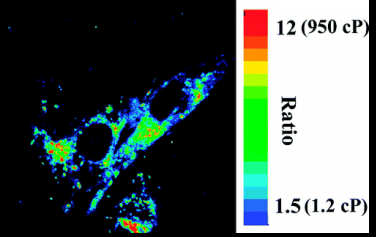
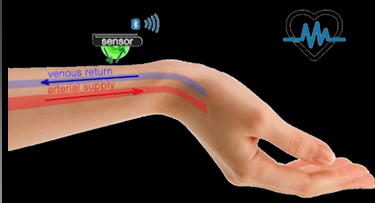
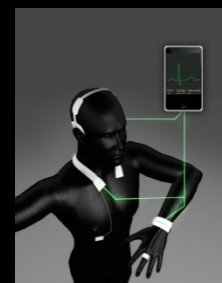
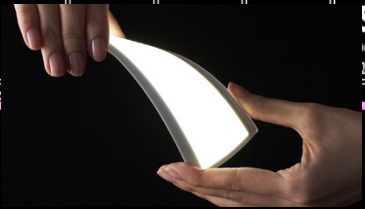
+ 多彩な元素  
→新奇の機能の導出

|                           |                               |                                 |                               |                                |                               |
|---------------------------|-------------------------------|---------------------------------|-------------------------------|--------------------------------|-------------------------------|
|                           |                               |                                 |                               |                                | 4<br>He<br>Helium<br>4.003    |
| 5<br>B<br>Boron<br>10.811 | 6<br>C<br>Carbon<br>12.011    | 7<br>N<br>Nitrogen<br>14.007    | 8<br>O<br>Oxygen<br>15.999    | 9<br>F<br>Fluorine<br>18.998   | 10<br>Ne<br>Neon<br>20.180    |
|                           | 14<br>Si<br>Silicon<br>28.086 | 15<br>P<br>Phosphorus<br>30.974 | 16<br>S<br>Sulfur<br>32.06    | 17<br>Cl<br>Chlorine<br>35.45  | 18<br>Ar<br>Argon<br>39.948   |
| 30<br>Zn<br>Zinc<br>65.38 | 31<br>Ga<br>Gallium<br>69.723 | 32<br>Ge<br>Germanium<br>72.631 | 33<br>As<br>Arsenic<br>74.922 | 34<br>Se<br>Selenium<br>78.971 | 35<br>Br<br>Bromine<br>79.904 |
|                           |                               |                                 |                               |                                | 36<br>Kr<br>Krypton<br>84.798 |

|                      |                       |                    |                       |                     |                                 |                                  |                                 |                                |                                 |                    |
|----------------------|-----------------------|--------------------|-----------------------|---------------------|---------------------------------|----------------------------------|---------------------------------|--------------------------------|---------------------------------|--------------------|
| 39.098               | 40.078                | 44.956             | 47.867                | 50.942              | 51.996                          | 54.938                           | 55.845                          | 58.933                         | 58.693                          | 63.546             |
| 37<br>Rb<br>Rubidium | 38<br>Sr<br>Strontium | 39<br>Y<br>Yttrium | 40<br>Zr<br>Zirconium | 41<br>Nb<br>Niobium | 42<br>Mo<br>Molybdenum<br>95.95 | 43<br>Tc<br>Technetium<br>98.907 | 44<br>Ru<br>Ruthenium<br>101.07 | 45<br>Rh<br>Rhodium<br>102.906 | 46<br>Pd<br>Palladium<br>106.42 | 47<br>Cu<br>Copper |
| 74                   | 75                    | 76                 | 77                    | 78                  | 79                              | 80                               | 81                              | 82                             | 83                              | 84                 |

## 応用展開

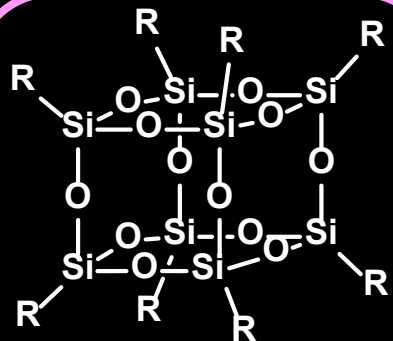
- 元素の新しい「顔」探し
- 既存材料の課題解決
  - 新奇材料の創成



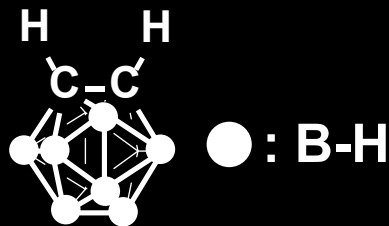
|                   |                    |                         |                    |                     |                     |                      |                   |                      |                        |                      |                    |                      |                     |                     |
|-------------------|--------------------|-------------------------|--------------------|---------------------|---------------------|----------------------|-------------------|----------------------|------------------------|----------------------|--------------------|----------------------|---------------------|---------------------|
| Acetum<br>227.028 | Thorium<br>232.038 | Protactinium<br>231.036 | Uranium<br>238.029 | Nepotium<br>237.048 | Plutonum<br>244.064 | Americium<br>243.061 | Curium<br>247.070 | Berkelium<br>247.070 | Californium<br>251.080 | Einsteinium<br>[254] | Fermium<br>257.095 | Mendelevium<br>258.1 | Nobelium<br>259.101 | Lawrencium<br>[262] |
|-------------------|--------------------|-------------------------|--------------------|---------------------|---------------------|----------------------|-------------------|----------------------|------------------------|----------------------|--------------------|----------------------|---------------------|---------------------|

# 最近の元素ブロック

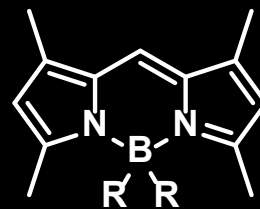
## <Element-blocks>



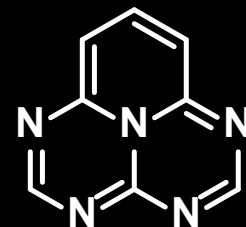
POSS



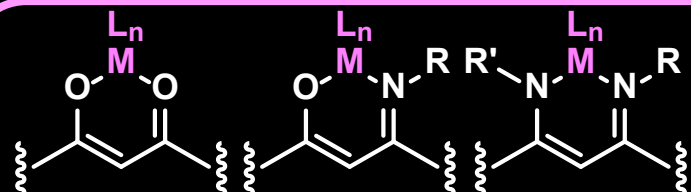
カルボラン



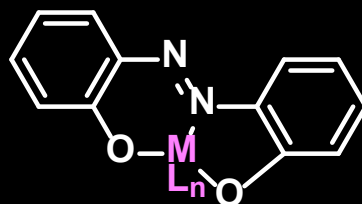
BODIPY



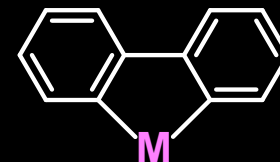
アザフェナレン



ケトイミン・ジイミン錯体



アゾベンゼン

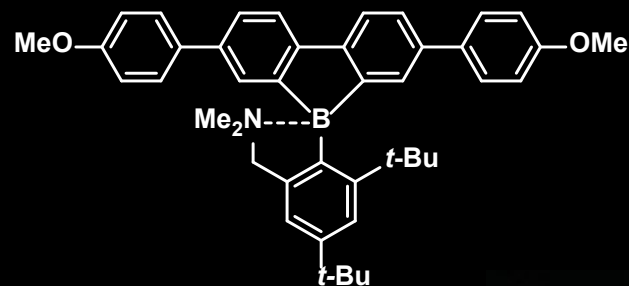
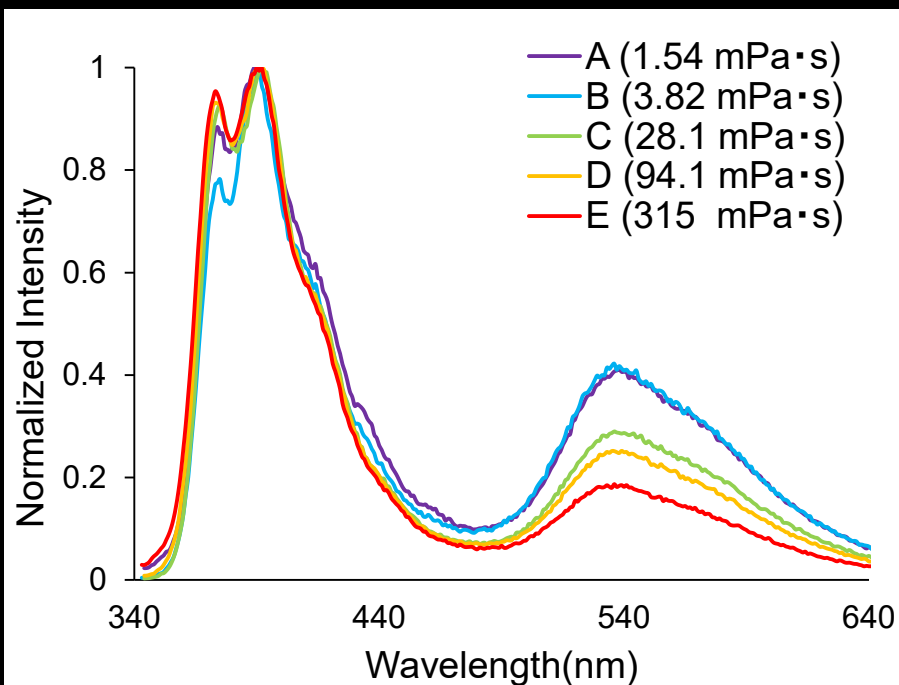


メタロフルオレン

主に発光材料

# 市販の油類の粘度測定

Bf-OMe  $1.0 \times 10^{-5}$  M

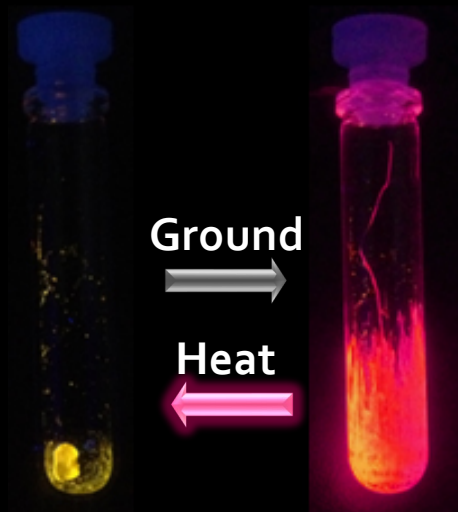
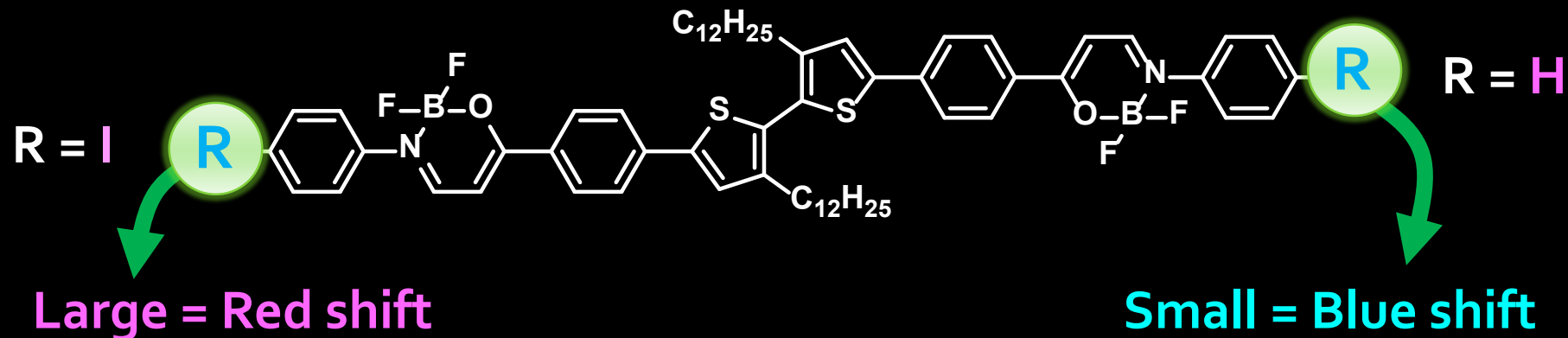


A B C D E

燃料の劣化の検出

|   |      | Bf-OMeからの結果 | 粘度計での結果 |
|---|------|-------------|---------|
| A | ガソリン | 1.54        | 4.39    |
| B | 灯油   | 3.82        | 4.99    |
| C | 軽油   | 28.1        | 28.0    |
| D | 重油1  | 94.1        | 55.9    |
| E | 重油2  | 315         | 242     |

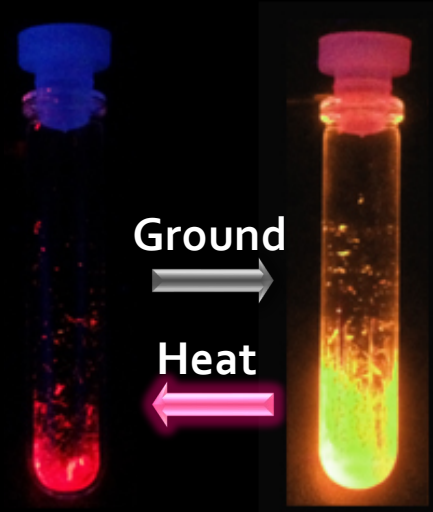
# メカノルミネッセントクロミズムの制御



yellow  $\Rightarrow$  red



Write & Erase



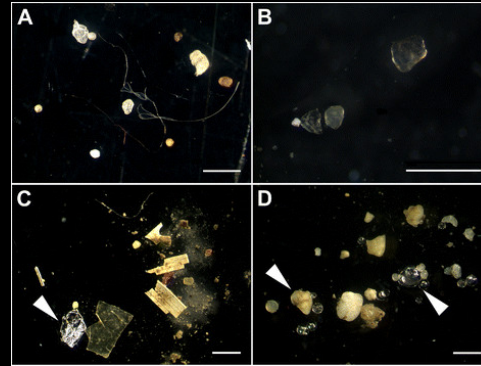
red  $\Rightarrow$  yellow

発光クロミズムの変化方向を置換基により制御した初めての例

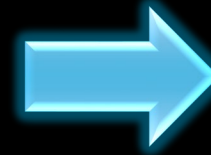


# プラスチックによる水汚染

## 高分子化学者として解決すべき緊急の問題



生物濃縮



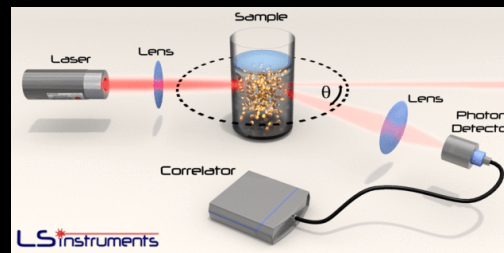
Wagner et al. *Env. Sci. Eur.* 2014, 26,  
DOI: 10.1186/s12302-014-0012-7

- 水中に長期間滞留し重金属等の有害物質を吸着
- 生物濃縮により摂取されている

既存の  
検出法



電子顕微鏡



光散乱



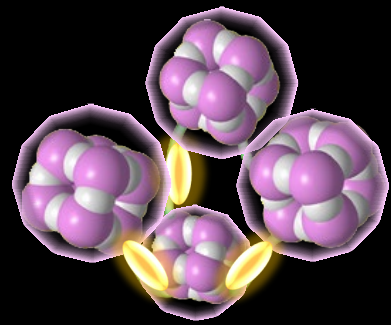
FT-IR

簡便に水の汚染度をチェックできるセンサーが必要

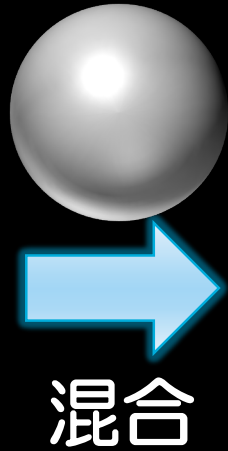


# プラスチック微粒子の蛍光検出

プラスチック  
微粒子

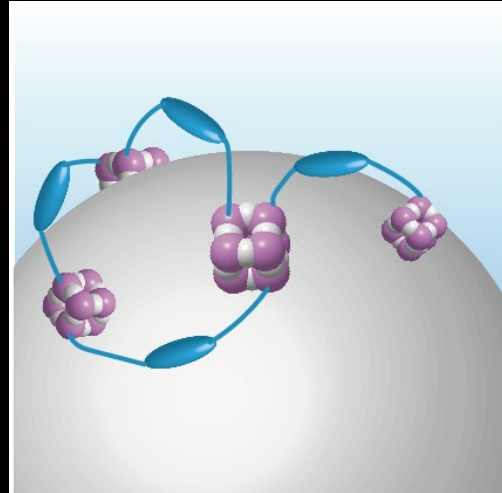


ハイブリッド  
ネットワーク



混合

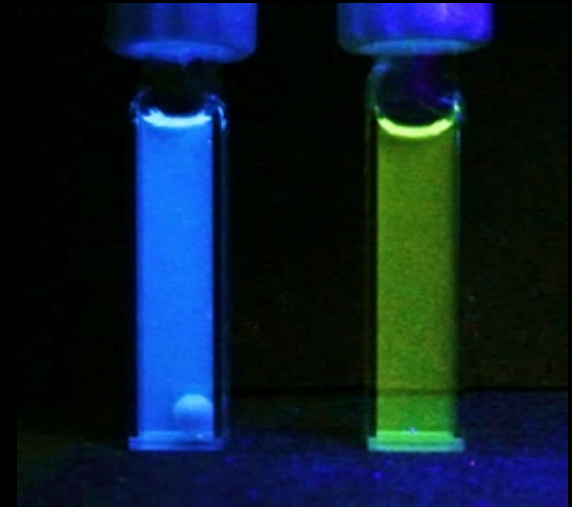
微粒子表面



POSS: 強く吸着  
→色素が外に放り出される

ポリスチレン  
粒子

Probe  
only



## 利点

- 簡便に混ぜるだけで色変化で検出可能
- 組成とサイズを識別可能

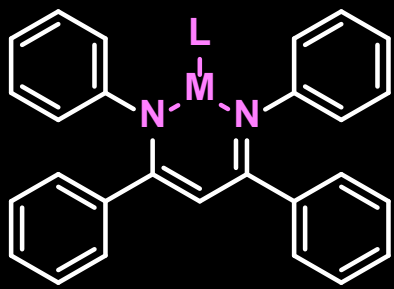
# 元素のコンプ目指して

高分子＋色々な元素  
→「元素材料」創出

|                                       |                                        |                                       |                                            |                                        |                                         |                                         |                                        |                                         |                                           |                                          |                                          |                                         |                                        |                                          |                                          |                                           |                                          |
|---------------------------------------|----------------------------------------|---------------------------------------|--------------------------------------------|----------------------------------------|-----------------------------------------|-----------------------------------------|----------------------------------------|-----------------------------------------|-------------------------------------------|------------------------------------------|------------------------------------------|-----------------------------------------|----------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------|------------------------------------------|
| 1<br><b>H</b><br>Hydrogen<br>1.008    |                                        |                                       |                                            |                                        |                                         |                                         |                                        |                                         |                                           |                                          |                                          |                                         |                                        |                                          |                                          |                                           | 2<br><b>He</b><br>Helium<br>4.003        |
| 3<br><b>Li</b><br>Lithium<br>6.941    | 4<br><b>Be</b><br>Beryllium<br>9.012   |                                       |                                            |                                        |                                         |                                         |                                        |                                         |                                           |                                          |                                          |                                         |                                        |                                          |                                          |                                           |                                          |
| 11<br><b>Na</b><br>Sodium<br>22.990   | 12<br><b>Mg</b><br>Magnesium<br>24.305 |                                       |                                            |                                        |                                         |                                         |                                        |                                         |                                           |                                          |                                          |                                         |                                        |                                          |                                          |                                           |                                          |
| 19<br><b>K</b><br>Potassium<br>39.098 | 20<br><b>Ca</b><br>Calcium<br>40.078   | 21<br><b>Sc</b><br>Scandium<br>44.956 | 22<br><b>Ti</b><br>Titanium<br>47.867      | 23<br><b>V</b><br>Vanadium<br>50.942   | 24<br><b>Cr</b><br>Chromium<br>51.996   | 25<br><b>Mn</b><br>Manganese<br>54.938  | 26<br><b>Fe</b><br>Iron<br>55.845      | 27<br><b>Co</b><br>Cobalt<br>58.933     | 28<br><b>Ni</b><br>Nickel<br>58.693       | 29<br><b>Cu</b><br>Copper<br>63.546      | 30<br><b>Zn</b><br>Zinc<br>65.38         | 31<br><b>Ga</b><br>Gallium<br>69.723    | 32<br><b>Ge</b><br>Germanium<br>72.631 | 33<br><b>As</b><br>Arsenic<br>74.922     | 34<br><b>Se</b><br>Selenium<br>78.971    | 35<br><b>Br</b><br>Bromine<br>79.904      | 36<br><b>Kr</b><br>Krypton<br>84.798     |
| 37<br><b>Rb</b><br>Rubidium<br>84.468 | 38<br><b>Sr</b><br>Strontium<br>87.62  | 39<br><b>Y</b><br>Yttrium<br>88.906   | 40<br><b>Zr</b><br>Zirconium<br>91.224     | 41<br><b>Nb</b><br>Niobium<br>92.906   | 42<br><b>Mo</b><br>Molybdenum<br>95.95  | 43<br><b>Tc</b><br>Technetium<br>98.907 | 44<br><b>Ru</b><br>Ruthenium<br>101.07 | 45<br><b>Rh</b><br>Rhodium<br>102.906   | 46<br><b>Pd</b><br>Palladium<br>106.42    | 47<br><b>Ag</b><br>Silver<br>107.868     | 48<br><b>Cd</b><br>Cadmium<br>112.414    | 49<br><b>In</b><br>Indium<br>114.818    | 50<br><b>Sn</b><br>Tin<br>118.711      | 51<br><b>Sb</b><br>Antimony<br>121.760   | 52<br><b>Te</b><br>Tellurium<br>127.6    | 53<br><b>I</b><br>Iodine<br>126.905       | 54<br><b>Xe</b><br>Xenon<br>131.29       |
| 55<br><b>Cs</b><br>Cesium<br>132.905  | 56<br><b>Ba</b><br>Barium<br>137.328   | 57-71<br>Lanthanides                  | 72<br><b>Hf</b><br>Hafnium<br>178.49       | 73<br><b>Ta</b><br>Tantalum<br>180.948 | 74<br><b>W</b><br>Tungsten<br>183.84    | 75<br><b>Re</b><br>Rhenium<br>186.207   | 76<br><b>Os</b><br>Osmium<br>190.23    | 77<br><b>Ir</b><br>Iridium<br>192.217   | 78<br><b>Pt</b><br>Platinum<br>195.085    | 79<br><b>Au</b><br>Gold<br>196.967       | 80<br><b>Hg</b><br>Mercury<br>200.592    | 81<br><b>Tl</b><br>Thallium<br>204.383  | 82<br><b>Pb</b><br>Lead<br>207.2       | 83<br><b>Bi</b><br>Bismuth<br>208.980    | 84<br><b>Po</b><br>Polonium<br>[209]     | 85<br><b>At</b><br>Astatine<br>[209]      | 86<br><b>Rn</b><br>Radon<br>[222]        |
| 87<br><b>Fr</b><br>Francium<br>[223]  | 88<br><b>Ra</b><br>Radium<br>[226]     | 89-103<br>Actinides                   | 104<br><b>Rf</b><br>Rutherfordium<br>[261] | 105<br><b>Db</b><br>Dubnium<br>[262]   | 106<br><b>Sg</b><br>Seaborgium<br>[266] | 107<br><b>Bh</b><br>Bohrium<br>[264]    | 108<br><b>Hs</b><br>Hassium<br>[269]   | 109<br><b>Mt</b><br>Meitnerium<br>[268] | 110<br><b>Ds</b><br>Darmstadtium<br>[269] | 111<br><b>Rg</b><br>Roentgenium<br>[272] | 112<br><b>Cn</b><br>Copernicium<br>[277] | 113<br><b>Nh</b><br>Nihonium<br>unknown | 114<br><b>Fl</b><br>Flerovium<br>[289] | 115<br><b>Mc</b><br>Moscovium<br>unknown | 116<br><b>Lv</b><br>Livermorium<br>[293] | 117<br><b>Ts</b><br>Tennessine<br>unknown | 118<br><b>Og</b><br>Oganesson<br>unknown |

|                                         |                                     |                                            |                                         |                                          |                                       |                                        |                                         |                                       |                                          |                                         |                                      |                                          |                                         |                                         |
|-----------------------------------------|-------------------------------------|--------------------------------------------|-----------------------------------------|------------------------------------------|---------------------------------------|----------------------------------------|-----------------------------------------|---------------------------------------|------------------------------------------|-----------------------------------------|--------------------------------------|------------------------------------------|-----------------------------------------|-----------------------------------------|
| 57<br><b>La</b><br>Lanthanum<br>138.905 | 58<br><b>Ce</b><br>Cerium<br>140.12 | 59<br><b>Pr</b><br>Praseodymium<br>140.908 | 60<br><b>Nd</b><br>Neodymium<br>144.242 | 61<br><b>Pm</b><br>Promethium<br>144.913 | 62<br><b>Sm</b><br>Samarium<br>150.36 | 63<br><b>Eu</b><br>Europium<br>151.964 | 64<br><b>Gd</b><br>Gadolinium<br>157.25 | 65<br><b>Tb</b><br>Terbium<br>158.925 | 66<br><b>Dy</b><br>Dysprosium<br>162.500 | 67<br><b>Ho</b><br>Holmium<br>164.930   | 68<br><b>Er</b><br>Erbium<br>167.259 | 69<br><b>Tm</b><br>Thulium<br>168.934    | 70<br><b>Yb</b><br>Ytterbium<br>173.055 | 71<br><b>Lu</b><br>Lutetium<br>174.967  |
| 89<br><b>Ac</b><br>Actinium<br>[227]    | 90<br><b>Th</b><br>Thorium<br>[232] | 91<br><b>Pa</b><br>Protactinium<br>[231]   | 92<br><b>U</b><br>Uranium<br>[238]      | 93<br><b>Np</b><br>Neptunium<br>[237]    | 94<br><b>Pu</b><br>Plutonium<br>[244] | 95<br><b>Am</b><br>Americium<br>[243]  | 96<br><b>Cm</b><br>Curium<br>[247]      | 97<br><b>Bk</b><br>Berkelium<br>[247] | 98<br><b>Cf</b><br>Californium<br>[251]  | 99<br><b>Es</b><br>Einsteinium<br>[254] | 100<br><b>Fm</b><br>Fermium<br>[257] | 101<br><b>Md</b><br>Mendelevium<br>[258] | 102<br><b>No</b><br>Nobelium<br>[259]   | 103<br><b>Lr</b><br>Lawrencium<br>[262] |

# 励起元素の規則性

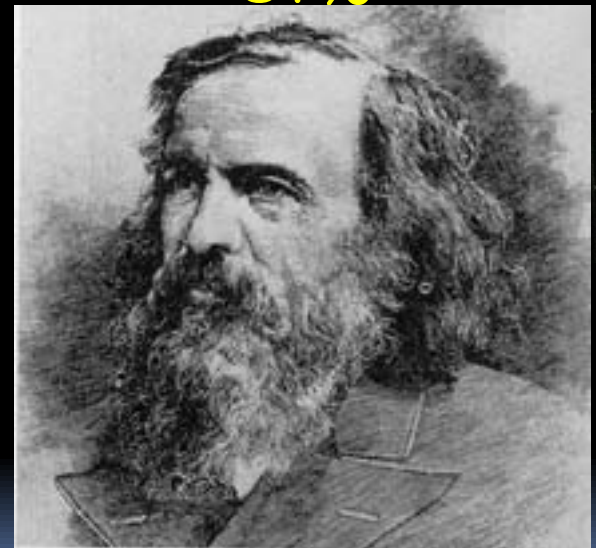
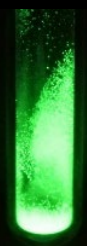
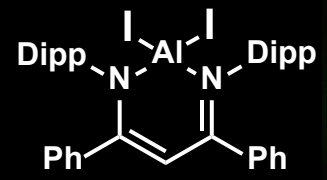


## 励起状態の性質

B  
固体蛍光効率  
96%



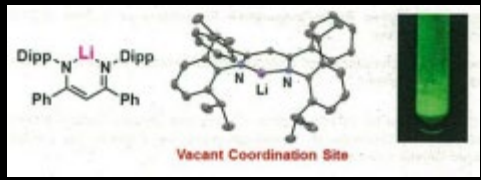
Al  
固体室温りん光効率  
57%



## 周期表の性質 (二基底状態)

- 電子受容性  
→ 想定通り

## 不可解な長波長発光



共通点？

|    |    |
|----|----|
| 13 | B  |
|    | Al |
|    | Ga |
|    | In |
|    | Tl |

動<→AIE

りん光

環境応答性

不明

+1での配位

励起状態での元素の新しい周期表作成  
第二のメンデレーエフ