

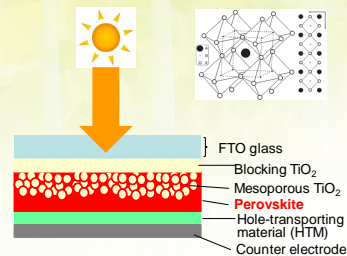
# 新規コバルト錯体をホール輸送層の添加剤として用いたペロブスカイト太陽電池

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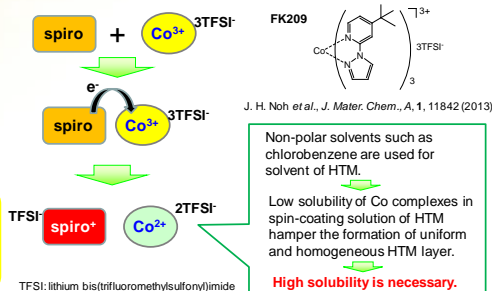
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## Introduction

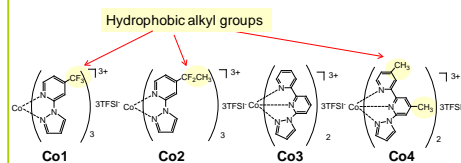
### Perovskite solar cell (PSC)



### Interaction between Co complexes and spiro-OMeTAD



## Structure of Co complexes



## Conductivity

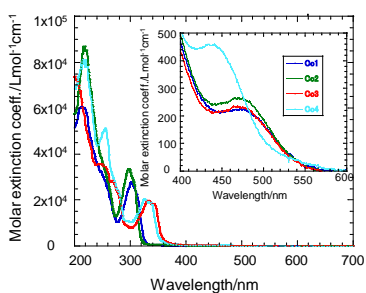
Table 2 Conductivities of undoped spiro-OMeTAD and doped spiro-OMeTAD (with Co1–Co4 or FK209) films<sup>a</sup> on glass substrates.

| Dopant | Conductivity (Scm <sup>-1</sup> ) |
|--------|-----------------------------------|
| None   | 5x10 <sup>-5</sup>                |
| Co1    | 3x10 <sup>-4</sup>                |
| Co2    | 3x10 <sup>-4</sup>                |
| Co3    | 3x10 <sup>-4</sup>                |
| Co4    | 1x10 <sup>-4</sup>                |
| FK209  | 1x10 <sup>-4</sup>                |

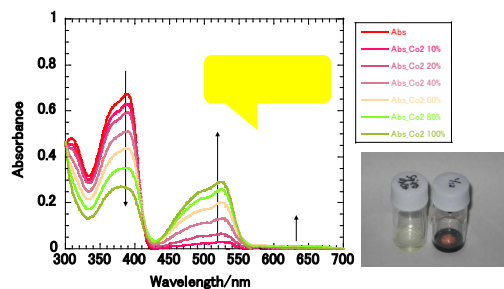
<sup>a</sup> Spiro-OMeTAD was added to LITFSI+TBP as an additive with the same concentration of cell fabrication.

The co-addition of Co1–Co4 is highly effective for increasing the conductivity of spiro-OMeTAD film.

## UV spectra

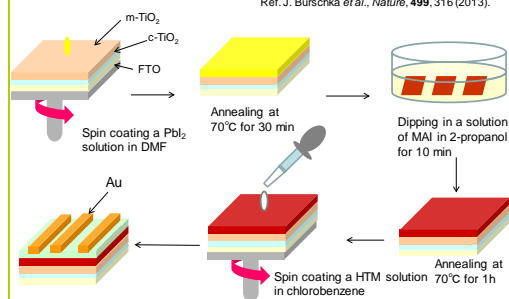


UV absorption spectra of Co1–Co4 in CH<sub>3</sub>CN. Inset shows an expanded view of the range 400–600 nm.



## Cell fabrication by 2step method

Ref. J. Burschka et al., Nature, 499, 316 (2013).



## Photovoltaic performance

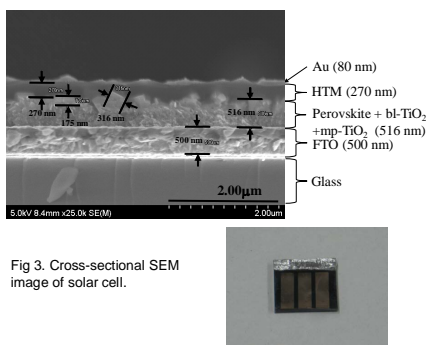


Fig 3. Cross-sectional SEM image of solar cell.

Table 3 Photovoltaic parameters of devices containing spiro-OMeTAD and LITFSI+TBP.<sup>a</sup>

| Complex          | $J_{sc}/\text{mA cm}^{-2}$ | $V_{oc}/\text{V}$ | FF        | PCE/%    |
|------------------|----------------------------|-------------------|-----------|----------|
| Blank            | 20.6±0.5                   | 0.95±0.02         | 0.66±0.02 | 12.9±0.6 |
| Co1 <sup>b</sup> | 20.2±0.6                   | 0.98±0.01         | 0.64±0.02 | 12.7±0.4 |
| Co2 <sup>b</sup> | 20.0±0.5                   | 0.98±0.02         | 0.66±0.02 | 12.8±0.4 |
| Co3 <sup>b</sup> | 14.7±1.2                   | 0.95±0.03         | 0.56±0.10 | 7.9±1.8  |
| Co4 <sup>b</sup> | 19.8±0.6                   | 0.96±0.02         | 0.64±0.02 | 12.2±0.5 |

<sup>a</sup> These values are from backward scans and are the average of 16–18 solar cells. <sup>b</sup> A concentration of 9 mol% dopant was added relative to spiro-OMeTAD.

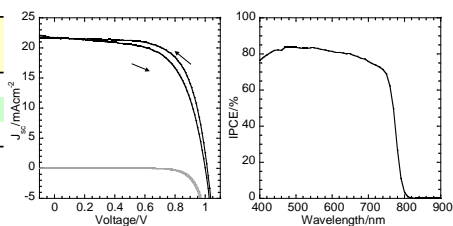
Table 4 Photovoltaic parameters of devices containing spiro-OMeTAD and added LITFSI+TBP as a function of Co2 concentration.<sup>a</sup>

|          | $J_{sc}/\text{mA cm}^{-2}$ | $V_{oc}/\text{V}$ | FF        | PCE/%    |
|----------|----------------------------|-------------------|-----------|----------|
| Blank    | 20.6±0.5                   | 0.95±0.02         | 0.66±0.02 | 12.9±0.6 |
| 4.5 mol% | 21.2±0.4                   | 1.00±0.01         | 0.68±0.01 | 14.2±0.4 |
| 9 mol%   | 20.0±0.5                   | 0.98±0.02         | 0.66±0.02 | 12.8±0.4 |

<sup>a</sup> These values are from backward scans and are the average of 16–18 solar cells.

Table 5 Photovoltaic parameters of best-performing devices containing 4.5 mol% Co2 or FK209 as dopant.

|       | Scan direction | $J_{sc}/\text{mA cm}^{-2}$ | $V_{oc}/\text{V}$ | FF    | PCE/% |
|-------|----------------|----------------------------|-------------------|-------|-------|
| Co2   | Backward       | 21.6                       | 1.014             | 0.676 | 14.8  |
|       | Forward        | 21.7                       | 1.000             | 0.625 | 13.6  |
| FK209 | Backward       | 20.8                       | 0.997             | 0.661 | 13.7  |
|       | Forward        | 21.4                       | 0.976             | 0.543 | 11.4  |



## Summary

- New cobalt complexes Co1–Co4 as dopants for spiro-OMeTAD (a frequently used HTM) were synthesized.
- These Co1–Co4 complexes have the suitable redox potentials for the oxidation of spiro-OMeTAD which eventually enhance the conductivity of spiro-OMeTAD film.
- The devices with Co1, Co2, and Co4 as dopant performed better than the device with Co3 because of the hydrophobic alkyl groups on the ligands.
- It was found that hydrophobic alkyl groups are important as dopants because they improve dopant solubility in the spin-coating solution.

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