What can you do with nothing?

How to make null results informative? A discussion.

Dr. Michèle B. Nuijten

@MicheleNuijten

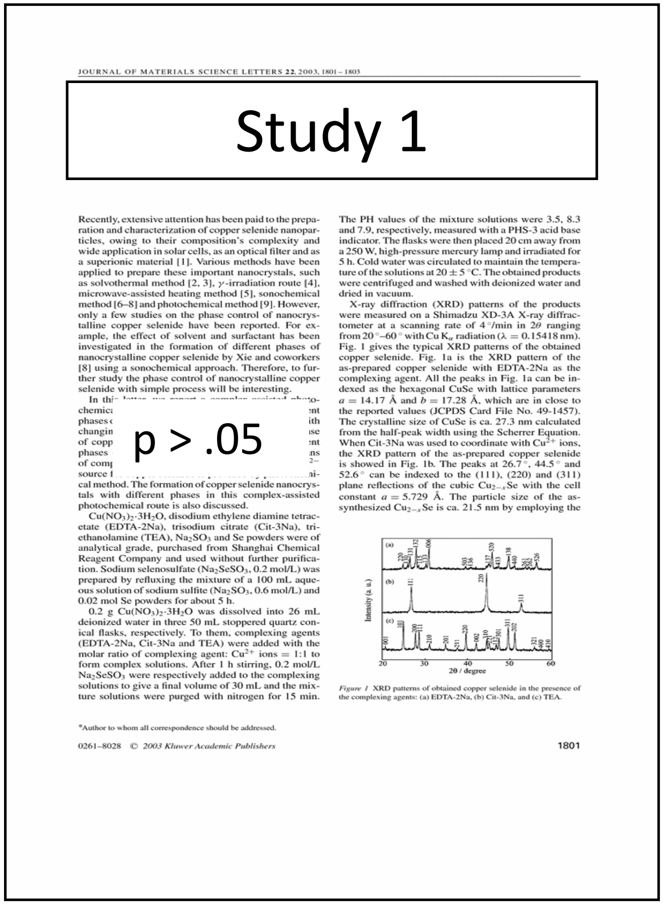
m.b.nuijten@uvt.nl

http://mbnuijten.com

Tilburg University

icps 2019
International Convention of Psychological Science

Single Study



JOURNAL OF MATERIALS SCIENCE LETTERS 22, 2003, 1801 – 1803

Study 1

Recently, extensive attention has been paid to the preparation and characterization of copper selenide nanoparticles, owing to their composition's complexity and wide application in solar cells, as an optical filter and as a superionic material [1]. Various methods have been applied to prepare these important nanocrystals, such as solvothermal method [2, 3], γ-irradiation route [4], microwave-assisted heating method [5], sonochemical method [6–8] and photochemical method [9]. However, only a few studies on the phase control of nanocrystalline copper selenide have been reported. For example, the effect of solvent and surfactant has been investigated in the formation of different phases of nanocrystalline copper selenide by Xie and coworkers [8] using a sonochemical approach. Therefore, to further study the phase control of nanocrystalline copper selenide with simple process will be interesting.

In thi[illegible]to-chemic[illegible]nt phases [illegible]ith changin[illegible]se of copp[illegible]nt phases [illegible]ns of com[illegible]2− source [illegible]ni-cal method. The formation of copper selenide nanocrystals with different phases in this complex-assisted photochemical route is also discussed.

p > .05

$Cu(NO_3)_2 \cdot 3H_2O$, disodium ethylene diamine tetracetate (EDTA-2Na), trisodium citrate (Cit-3Na), triethanolamine (TEA), Na_2SO_3 and Se powders were of analytical grade, purchased from Shanghai Chemical Reagent Company and used without further purification. Sodium selenosulfate (Na_2SeSO_3, 0.2 mol/L) was prepared by refluxing the mixture of a 100 mL aqueous solution of sodium sulfite (Na_2SO_3, 0.6 mol/L) and 0.02 mol Se powders for about 5 h.

0.2 g $Cu(NO_3)_2 \cdot 3H_2O$ was dissolved into 26 mL deionized water in three 50 mL stoppered quartz conical flasks, respectively. To them, complexing agents (EDTA-2Na, Cit-3Na and TEA) were added with the molar ratio of complexing agent: Cu^{2+} ions = 1:1 to form complex solutions. After 1 h stirring, 0.2 mol/L Na_2SeSO_3 were respectively added to the complexing solutions to give a final volume of 30 mL and the mixture solutions were purged with nitrogen for 15 min. The PH values of the mixture solutions were 3.5, 8.3 and 7.9, respectively, measured with a PHS-3 acid base indicator. The flasks were then placed 20 cm away from a 250 W, high-pressure mercury lamp and irradiated for 5 h. Cold water was circulated to maintain the temperature of the solutions at 20 ± 5 °C. The obtained products were centrifuged and washed with deionized water and dried in vacuum.

X-ray diffraction (XRD) patterns of the products were measured on a Shimadzu XD-3A X-ray diffractometer at a scanning rate of 4 °/min in 2θ ranging from 20 °–60 ° with Cu K_α radiation ($\lambda = 0.15418$ nm). Fig. 1 gives the typical XRD patterns of the obtained copper selenide. Fig. 1a is the XRD pattern of the as-prepared copper selenide with EDTA-2Na as the complexing agent. All the peaks in Fig. 1a can be indexed as the hexagonal CuSe with lattice parameters $a = 14.17$ Å and $b = 17.28$ Å, which are in close to the reported values (JCPDS Card File No. 49-1457). The crystalline size of CuSe is ca. 27.3 nm calculated from the half-peak width using the Scherrer Equation. When Cit-3Na was used to coordinate with Cu^{2+} ions, the XRD pattern of the as-prepared copper selenide is showed in Fig. 1b. The peaks at 26.7 °, 44.5 ° and 52.6 ° can be indexed to the (111), (220) and (311) plane reflections of the cubic $Cu_{2-x}Se$ with the cell constant $a = 5.729$ Å. The particle size of the as-synthesized $Cu_{2-x}Se$ is ca. 21.5 nm by employing the

Figure 1 XRD patterns of obtained copper selenide in the presence of the complexing agents: (a) EDTA-2Na, (b) Cit-3Na, and (c) TEA.

*Author to whom all correspondence should be addressed.

Suggestions

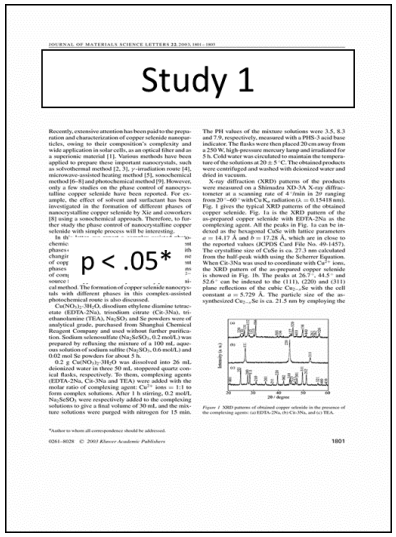
- Use Bayes factors
  - *"Are my data ambiguous or evidence for H0?"*
- Explore hidden moderators

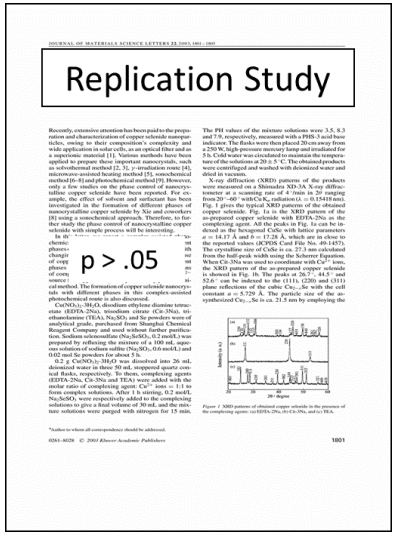
Discussion

- Hindsight bias?
- Test hypothesized moderators in new & preregistered study

PREREGISTERED

Replication Study





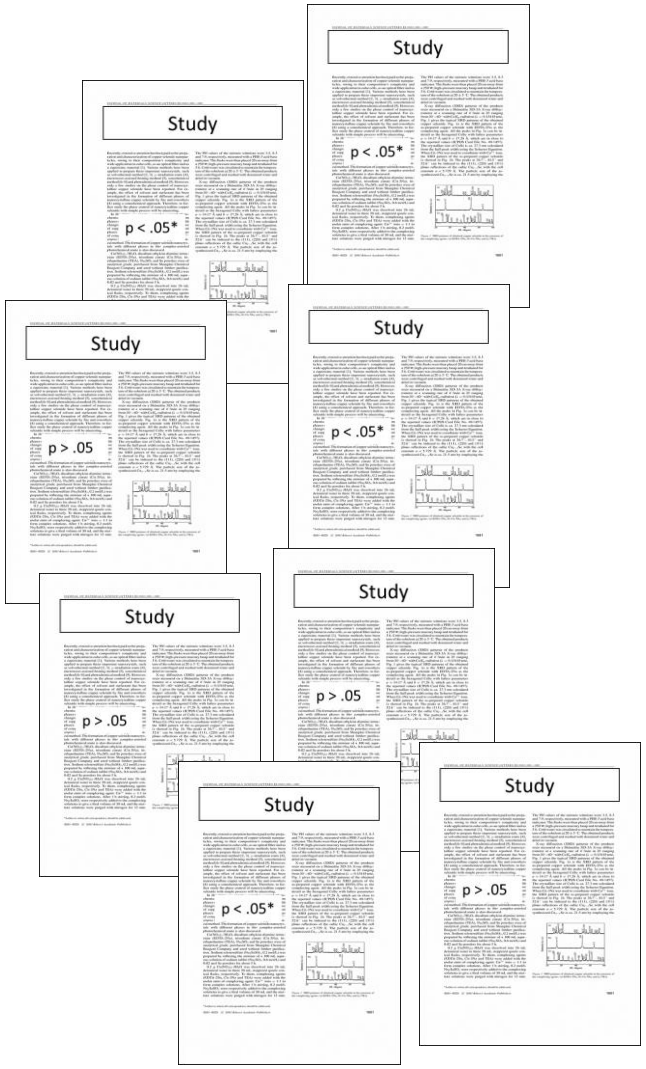
Suggestions

- Contact original authors
- Replication more value, because no chance of p-hacking?

Discussion

- Paper should be replicable without contacting the authors
- How to avoid p-hacking altogether?

Meta-Analysis



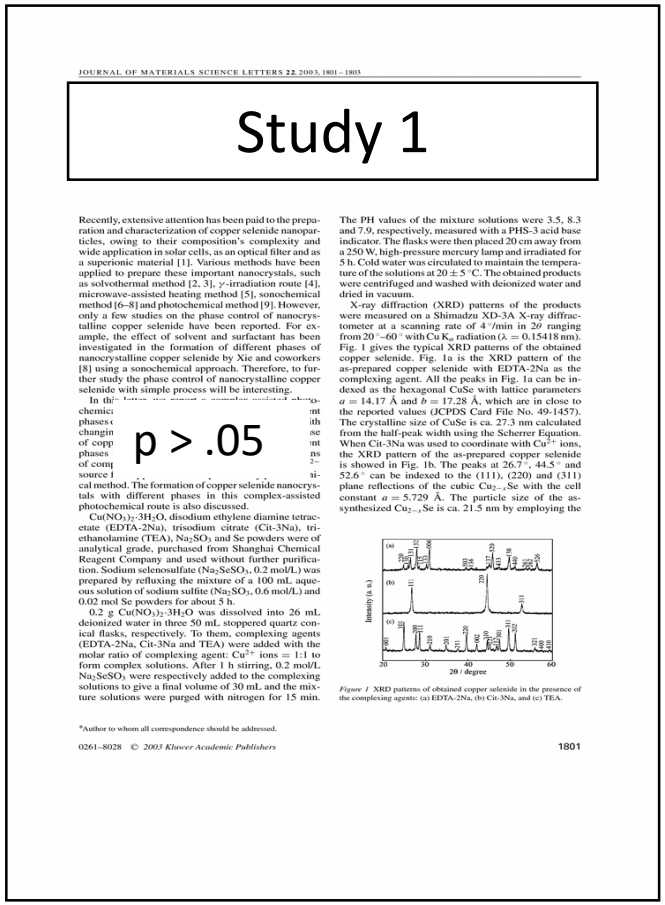
Suggestions

- Combine evidence in a meta-analysis

Discussion

- Only as good as the input…
- Ideally:
  - Preregistered
  - Transparent

Single Study



JOURNAL OF MATERIALS SCIENCE LETTERS 22, 2003, 1801 – 1803

Study 1

p > .05

Recently, extensive attention has been paid to the preparation and characterization of copper selenide nanoparticles, owing to their composition's complexity and wide application in solar cells, as an optical filter and as a superionic material [1]. Various methods have been applied to prepare these important nanocrystals, such as solvothermal method [2, 3], γ-irradiation route [4], microwave-assisted heating method [5], sonochemical method [6–8] and photochemical method [9]. However, only a few studies on the phase control of nanocrystalline copper selenide have been reported. For example, the effect of solvent and surfactant has been investigated in the formation of different phases of nanocrystalline copper selenide by Xie and coworkers [8] using a sonochemical approach. Therefore, to further study the phase control of nanocrystalline copper selenide with simple process will be interesting.

In this letter, we report a complex-assisted photochemical route to synthesize different phases of copper selenide nanocrystals at room temperature by a simple photochemical method. The formation of copper selenide nanocrystals with different phases in this complex-assisted photochemical route is also discussed.

$Cu(NO_3)_2{\cdot}3H_2O$, disodium ethylene diamine tetraacetate (EDTA-2Na), trisodium citrate (Cit-3Na), triethanolamine (TEA), Na_2SO_3 and Se powders were of analytical grade, purchased from Shanghai Chemical Reagent Company and used without further purification. Sodium selenosulfate (Na_2SeSO_3, 0.2 mol/L) was prepared by refluxing the mixture of a 100 mL aqueous solution of sodium sulfite (Na_2SO_3, 0.6 mol/L) and 0.02 mol Se powders for about 5 h.

0.2 g $Cu(NO_3)_2{\cdot}3H_2O$ was dissolved into 26 mL deionized water in three 50 mL stoppered quartz conical flasks, respectively. To them, complexing agents (EDTA-2Na, Cit-3Na and TEA) were added with the molar ratio of complexing agent: Cu^{2+} ions = 1:1 to form complex solutions. After 1 h stirring, 0.2 mol/L Na_2SeSO_3 were respectively added to the complexing solutions to give a final volume of 30 mL and the mixture solutions were purged with nitrogen for 15 min. The PH values of the mixture solutions were 3.5, 8.3 and 7.9, respectively, measured with a PHS-3 acid base indicator. The flasks were then placed 20 cm away from a 250 W, high-pressure mercury lamp and irradiated for 5 h. Cold water was circulated to maintain the temperature of the solutions at 20 ± 5 °C. The obtained products were centrifuged and washed with deionized water and dried in vacuum.

X-ray diffraction (XRD) patterns of the products were measured on a Shimadzu XD-3A X-ray diffractometer at a scanning rate of 4 °/min in 2θ ranging from 20 °–60 ° with Cu K_α radiation (λ = 0.15418 nm). Fig. 1 gives the typical XRD patterns of the obtained copper selenide. Fig. 1a is the XRD pattern of the as-prepared copper selenide with EDTA-2Na as the complexing agent. All the peaks in Fig. 1a can be indexed as the hexagonal CuSe with lattice parameters a = 14.17 Å and b = 17.28 Å, which are in close to the reported values (JCPDS Card File No. 49-1457). The crystalline size of CuSe is ca. 27.3 nm calculated from the half-peak width using the Scherrer Equation. When Cit-3Na was used to coordinate with Cu^{2+} ions, the XRD pattern of the as-prepared copper selenide is showed in Fig. 1b. The peaks at 26.7 °, 44.5 ° and 52.6 ° can be indexed to the (111), (220) and (311) plane reflections of the cubic $Cu_{2-x}Se$ with the cell constant a = 5.729 Å. The particle size of the as-synthesized $Cu_{2-x}Se$ is ca. 21.5 nm by employing the

Figure 1 XRD patterns of obtained copper selenide in the presence of the complexing agents: (a) EDTA-2Na, (b) Cit-3Na, and (c) TEA.

*Author to whom all correspondence should be addressed.

0261–8028 © 2003 Kluwer Academic Publishers

Suggestions

- Use Bayes factors
  - *"Are my data ambiguous or evidence for H0?"*
- Explore hidden moderators

Discussion

- Test hypothesized moderators in new & preregistered study
- Share data & materials to facilitate meta-analysis

How to make null results informative?

How to make ~~null~~ results informative?