**Socratic Prompting with Argo: Assessment**

Mustafa Unal (MSD, Emerging Materials Group)

**Original Prompt:**

“I want to calculate the oxidation rate of lead and bismuth thin films. Assume that oxidation occurs at 25 °C, 0% humidity, and under ambient conditions. How can the oxidation rate be calculated, and what is the required time to oxidize a 500 nm thin film?”

**Socratic Reformulation:**

“What factors influence the oxidation rate of lead and bismuth thin films, and how can we determine the time required to oxidize a 500 nm film under specified conditions?”

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| **Principles** | **(Follow-Up) Prompts** |
| **Dialectic** | **Original Prompt:**  “What factors influence the oxidation rate of lead and bismuth thin films, and how can we determine the time required to oxidize a 500 nm film under specified conditions? |
| **Hypothesis Elimination** | **Follow-up Prompt 1:**  “How do we define the parabolic rate law for oxidation, and what assumptions underlie its application to lead and bismuth thin films?” |
| **Recollection** | **Follow-up Prompt 2:**  “What experimental data or literature values exist for the oxidation rates of lead and bismuth under similar conditions, and how can these inform our calculations?” |
| **Dialectic** | **Follow-up Prompt 3:**  “If the oxidation rate deviates from the expected parabolic behavior, what alternative mechanisms could explain the observed kinetics, and how might these affect the estimated time for complete oxidation?” |

1. **Motivation**

*Why is this problem important in chemistry/materials science?*

Metal thin films tend to oxidize due to environmental conditions, leading to the degradation of device performance. To mitigate this issue, devices are either isolated from environmental exposure or designed with carefully selected metals. However, some applications require the use of thin films that are highly prone to rapid oxidation, such as Pb and Bi. The oxidation of metal thin films has typically been studied at high temperatures, while corrosion of metal electrodes at room temperature remains less explored. Understanding oxidation rates and developing strategies to mitigate them are crucial for extending the lifespan of these devices.

*What challenges exist in solving this problem using traditional LLM approaches?*

Traditional LLMs assume a parabolic oxidation mechanism and provide the necessary formulations for calculations based on this assumption. Additionally, they perform calculations using predefined parabolic rate constants. However, when I provided a reference article for rate constant calculations, the model struggled to extract data from graphs and determine the oxidation mechanism described in the paper. Although the paper explicitly mentioned a logarithmic dependence on oxide thickness, the traditional LLM incorrectly concluded that the mechanism could be either logarithmic or parabolic.

*How could a structured Socratic approach improve reasoning and outcomes?*

Socratic approach did not help much in this situation. While traditional approach showed required equation to calculate with literature data, Socratic LLM did not provided any. It was only given with follow up prompts. However, Socratic LLM is successful on not directly assuming metal thin films has parabolic oxidation rate.

1. **The Mixed Socratic Prompt Method Used**
2. **What Are the Prompts Used?**

***Original Prompt:***

“I want to calculate the oxidation rate of lead and bismuth thin films. Assume that oxidation occurs at 25 °C, 0% humidity, and under ambient conditions. How can the oxidation rate be calculated, and what is the required time to oxidize a 500 nm thin film?”

***Socratic Reformulation:***

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1. **What Are the Outcomes of This Example?**

*How did the LLM refine its answers over iterations?*

Socratic LLM provided short, focused answers without many details. In order to learn details, follow-up prompts need to be used. When reference article provided to Socratic LLM, it was lack on finding related parts, rather summarizing findings in the article.

*What key insights or discoveries emerged?*

NONE!

*Any unexpected results or challenges?*

Not found

1. **Comparison to a Non-Socratic Approach**

*How did reasoning depth, self-correction, and hypothesis refinement compare?*

Traditional LLM response is much better than Socratic LLM. It can analyze the reference article provided much efficiently and can find related parts with the topic. ARGO is not good on article analysis overall!

*Would a traditional direct-answer prompt have produced different results?*

Traditional direct-answer prompt produced better results. It provided equations and mechanisms for me to calculate with reference data.

*Did the Socratic method improve clarity, adaptability, or accuracy?*

No. It did not. I was lack on analyzing reference article according to the topic and question asked. It could not follow the original prompt.