**Socratic Prompting with Argo: Assessment**

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**Original Prompt:**

“What are the mechanisms that leads to degradation on the performance of CsPbBr3 radiation detectors used in X-ray and gamma-ray detection applications?”

**Socratic Reformulation:**

“What are the primary hypotheses explaining the degradation mechanisms in CsPbBr3 radiation detectors, and how can we systematically evaluate these hypotheses to understand their impact on performance in X-ray and gamma-ray detection?”

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| **Principles** | **(Follow-Up) Prompts** |
| **Dialectic** | **Original Prompt:**  “What are the mechanisms that leads to degradation on the performance of CsPbBr3 radiation detectors used in X-ray and gamma-ray detection applications?” |
| **Induction** | **Follow-up Prompt 1:**  “Which of the identified degradation mechanisms are most supported by experimental evidence, and how can we design experiments to isolate and test each mechanism's impact on detector performance?” |
| **Analogy** | **Follow-up Prompt 2:**  “Are there known cases where similar perovskite materials exhibit different degradation behaviors under comparable conditions, and what does this suggest about the unique properties of CsPbBr3?” |
| **Recollection** | **Follow-up Prompt 3:**  “How do the observed degradation patterns in CsPbBr3 detectors compare to those in other radiation detection materials, and what historical studies provide insights into mitigating these effects?” |

1. **Motivation**

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

CsPbBr3 crystals are promising candidates for X-ray and gamma-ray detection applications. They offer balanced transport properties, which help mitigate polarization issues. CsPbBr3 has similar mass attenuation coefficients to CdZnTe, a commercially available radiation detector material. Furthermore, it can operate at higher temperatures compared to CdZnTe. However, due to inherent instabilities associated with the perovskite family, these detectors are not yet suitable for commercial applications. Addressing these stability challenges could usher in an era of more affordable cancer treatment, enhanced nuclear security, and improved countermeasures against nuclear terrorism.

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

Traditional LLMs list all possible degradation mechanisms, not limited to radiation detection applications but also including those relevant to solar cells, LEDs, and quantum dots. The definition of degradation mechanisms is broader in this context. For example, a radiation detector is not exposed to temperatures high enough to cause material decomposition, yet thermal instability is still listed as a concern. Among the seven identified instability mechanisms, three are not applicable to this specific application.

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

Socratic approach listed related mechanisms. Additionally. For each degradation mechanism, it points out specific conditions. For example, traditional LLM mentioned moisture sensitivity but Socratic LLM changed the title of this subsection as environmental factors and added oxygen, which is more accurate. Furthermore, Thermal effects were explained as exposure to high temperatures during operation or storage. This change is more logical. Lastly, follow-up prompts are more targeted and easy to continue reasoning with LLM in Socratic approach.

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

***Original Prompt:***

“What are the mechanisms that leads to degradation on the performance of CsPbBr3 radiation detectors used in X-ray and gamma-ray detection applications?”

***Socratic Reformulation:***

“What are the primary hypotheses explaining the degradation mechanisms in CsPbBr3 radiation detectors, and how can we systematically evaluate these hypotheses to understand their impact on performance in X-ray and gamma-ray detection?”

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

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

Traditional LLM just listed several categories related to CsPbBr3, not specifically for radiation detection area. It gives only a general response. On the other hand, the Socratic approach helped to refine the reasoning by providing more follow-up prompts.

*What key insights or discoveries emerged?*

Socratic approach helped to refine degradation mechanisms and how to text their effects individually on detector performance.

*Any unexpected results or challenges?*

Not found

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

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

The traditional LLM does not do reasoning for the given application area, but considering whole possible applications for CsPbBr3, even though it was stated as X-ray and gamm-ray detection applications in the first prompt. Socratic approach stayed in the frame of the first prompt, provided higher reasoning depth and follow up prompts help to obtain deeper understanding on the topic.

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

Traditional approach gives only general responses, which can be guessed by any person working on perovskite materials.

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

Overall, I am satisfied with the response of Socratic method. It provides short and accurate response.