4　シャー芯の芯じられないリシャイクル

～　折れたシャー芯たちを救え！　～

Unbelievable Recycling of Mechanical Pencil Leads

～　Save Broken Leads!　～

要旨　折れて使えなくなったシャープペンシルの芯や鉛筆の芯を再利用し、黒鉛と小麦粘土を混ぜて筆記具を作ることを試みた。材料比や焼成方法、持ち手の工夫により、簡易的な筆記具として実用可能なレベルに達した。環境負荷軽減やリサイクルの新たな可能性を示した点に意義がある。

Abstract　We attempted to recycle broken mechanical pencil leads by mixing them with wheat clay to create a new writing instrument. By adjusting the material ratio, baking method, and grip design, we achieved a level of functionality suitable for simple use. This study highlights a new possibility for recycling and reducing environmental impact.

1. Research Background, Purpose, and Significance

1.1 Research Background

Mechanical pencil leads (hereafter “leads”) are difficult to use up completely, and many of them, including broken pieces, are discarded without being used. These discarded leads are incinerated, releasing carbon dioxide and negatively impacting the environment. In recent years, the SDGs (Sustainable Development Goals) have been emphasized, and contributions to environmental protection are increasingly required. Against this backdrop, this study was conducted to explore ways of reusing discarded leads in order to reduce environmental burdens.

1.2 Research Question and Previous Studies/Examples

The research question is: *“Is there a way to reuse mechanical pencil leads for their original purpose as writing tools?”*

In our search, we could not find any previous studies on reusing leads as writing instruments. However, we did find an example introduced in *“We came up with ideas to reuse mechanical pencil leads!”*, in which the leads were reused as cactus spines. However, this was not a case of reuse for writing purposes.

1.3 Research Purpose and Significance

Since previous studies and examples did not address reusing leads as writing tools, the purpose of this study is to develop a method to reuse discarded leads as writing instruments. The significance lies in reducing economic burdens through reuse, making effective use of resources by recycling broken leads, and reducing carbon dioxide emissions during disposal, thereby lowering environmental impact.

1.4 Hypothesis and Rationale

We focused on the fact that the main components of pencil leads are graphite and clay, and hypothesized that graphite could be substituted with broken leads, and the clay component with wheat clay, to reuse broken leads as writing instruments.

According to *How Pencils Are Made* (Mitsubishi Pencil Co., Ltd.), pencil leads (HB) are made by mixing graphite and clay in a 7:3 ratio, shaping, and firing them at high temperatures (1000-2000℃). While graphite can be substituted with broken leads, our initial idea was to use pottery clay for the clay portion, which also requires high-temperature firing (~1000℃). However, producing such high heat was impractical, and handling it posed safety risks. From a practical standpoint, a material that does not require such extreme conditions was preferable,

so we substituted wheat clay instead. Wheat clay has similar shaping and firing processes, is softer and thus more suitable, and can be baked in a toaster. However, unlike pencil leads fired at very high temperatures, wheat clay differs in binding strength and hardness, meaning identical performance cannot be expected.

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2. Study 1: Reforming Pencil Lead into Writing Material

2.1 Purpose and Relation to Research Question and Hypothesis

This experiment tested the hypothesis by reforming graphite (from leads) and wheat clay into writing tools. Whether the produced tools could write legible text and withstand practical use served as evidence for or against the hypothesis.

2.2 Research and Analytical Methods

The research followed these six steps (later experiments varied only in ratios of ingredients):

1. Extract leads from pencils.
2. Grind collected pencil leads and mechanical pencil leads into powder using a mortar.
3. Make wheat clay by mixing salt, flour, and water.
4. Mix graphite powder and wheat clay.
5. Pack the mixture into straws, compressing into cylindrical sticks.
6. Bake the sticks in a toaster (200℃, 15 minutes).

This method was inspired by the process of making pencils—mixing clay and graphite, compressing, and baking. We chose wheat clay for its accessibility, pencil-like hardness, and compatibility with oven baking.

2.3 Results

We successfully reformed the material into writing tools. The writing was lighter compared to a regular pencil, but the characters were legible, and the tool was functional. However, the writing surface was rough, lacking smoothness, and the ratio of ingredients was imprecise.

2.4 Discussion

The lighter writing suggests insufficient graphite content. Measuring and adjusting the ratio of graphite to other ingredients might produce writing closer in quality to commercial pencils.

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3. Study 2: Varying the Ratio of Graphite and Wheat Clay

3.1 Purpose and Relation to Research Question and Hypothesis

Since Study 1 demonstrated that leads could be reformed into functional tools, this study aimed to find an optimal graphite-to-wheat-clay ratio closer to commercial pencils. This also tested whether graphite from broken leads could substitute pencil materials as hypothesized.

3.2 Methods

Commercial powdered graphite was used for consistency and quantity.
Steps were the same as in Study 1, but ratios were varied as follows:

Sample	Graphite	Flour	Salt	Water
1	15 g	10 g	5 g	60 g
2	5 g	10 g	5 g	35 g
3	3 g	10 g	5 g	25 g
4	1 g	10 g	5 g	25 g

3.3 Results

Samples 2, 3, and 4 did not write. Sample 1 could write, but felt like a crayon rather than a pencil, though the writing was dark.

3.4 Discussion

Unlike Study 1, where lead powder worked, Study 2 using laboratory graphite powder mostly failed. This suggests the graphite powder used differed structurally from pencil graphite. Sample 1's darkness suggests that increasing graphite proportion might enhance darkness regardless of graphite type. Future experiments should compare lead-derived graphite and laboratory graphite directly.

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4. Study 3: Using Crushed Lead Pieces for Ratio Comparison

4.1 Purpose and Relation to Research Question and Hypothesis

Study 2 suggested that graphite type mattered. Therefore, in Study 3, crushed pencil leads (instead of lab graphite) were used in ratios similar to Sample 1, to test if reformed writing tools function better.

4.2 Methods

1. Extract leads from pencils and mechanical pencils.
2. Grind into powder.
3. Make wheat clay (flour + salt + water).
4. Mix measured amounts according to the table:

Sample	Graphite	Flour	Salt	Water
1	15 g	10 g	5 g	11.23 g
2	17.5 g	5 g	2.5 g	9.45 g

5. Pack into straws and compress into sticks.
6. Bake in toaster (200℃, 15 minutes).

4.3 Results

Both samples produced legible writing, but shading was inconsistent. When pressed hard, the cores crumbled.

4.4 Discussion

The fragility may be due to longer core length, which increases leverage and stress. Inconsistent shading likely resulted from incomplete grinding, leaving larger fragments unmixed. The weakness appeared inherent to wheat clay, not underbaking, as pieces were sufficiently fired.

Comparison showed that lab graphite produced crayon-like marks, while crushed leads yielded more pencil-like writing. This difference is attributed to structural differences in graphite.

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5. Study 4: Forming a Holder

5.1 Purpose and Relation to Research Question and Hypothesis

Study 3 showed shorter cores were more durable, but too short to hold comfortably. Thus, a holder was added to make short cores usable and prevent hands from being stained, bringing the experiment closer to answering the research question.

5.2 Methods

1. Soften “Oyumaru” plastic clay in hot water (100℃).
2. Shape it into a pencil-like cylinder and insert the core.
3. Cool in refrigerator until hardened.

5.3 Results

With the holder, writing became much easier, though quality was still inferior to commercial

pencils.

5.4 Discussion

The holder improved usability significantly. While unsuitable for high-quality, everyday writing, the product could substitute low-grade tools such as survey “peg pencils.”

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6. Conclusion and Future Prospects

6.1 Conclusion

We succeeded in creating a writing tool from powdered leads and pencils. Although weaker and lighter than commercial pencils, adding a holder allowed practical use comparable to peg pencils. Using 0.5 cm straws as molds made processing easier. Both the cores and holders can be reused, aligning with SDGs by producing fully recyclable writing tools.

6.2 Future Prospects

The tool could substitute peg pencils for surveys and potentially find other niche uses. If materials such as discarded flour from restaurants are used, the product could be entirely sourced from recycled resources, further contributing to SDG goals.

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7. Acknowledgements

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8. References

1. *How Pencils Are Made* | Mitsubishi Pencil Co., Ltd. https://www.mpuni.co.jp/special/tour/pencil.html

2. *We came up with ideas to reuse mechanical pencil leads!* #Idea #IdeaCreator #Stationery https://youtube.com/watch?v=Cbr3nVz3nSA