

From Waste to Value: Spent Coffee Grounds Oil

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Motivation

As greenhouse gases (GHGs) must be severely reduced and unadorned **sustainability** must be practised, insufficient resource consumption and industrial pathways are tackled. A climate-neutral, **circular economy** is the answer that can only be reached when all valuable resources are considered, and **no waste** is generated.



Coffee grounds still hold **valuable content after brewing**, depending on the extraction method used, about **10-20 wt% of oil** can be extracted from the dried grounds.

Concept: From Waste to Value

After the consumption of coffee, used coffee grounds are left as residue in **significant amounts** but are mainly just disposed of in landfills. As they still contain multiple precious components like oils, they might be of interest as a **sustainable** and **industrially relevant feedstock** for **biofuel** or **bio-lubricant** production.

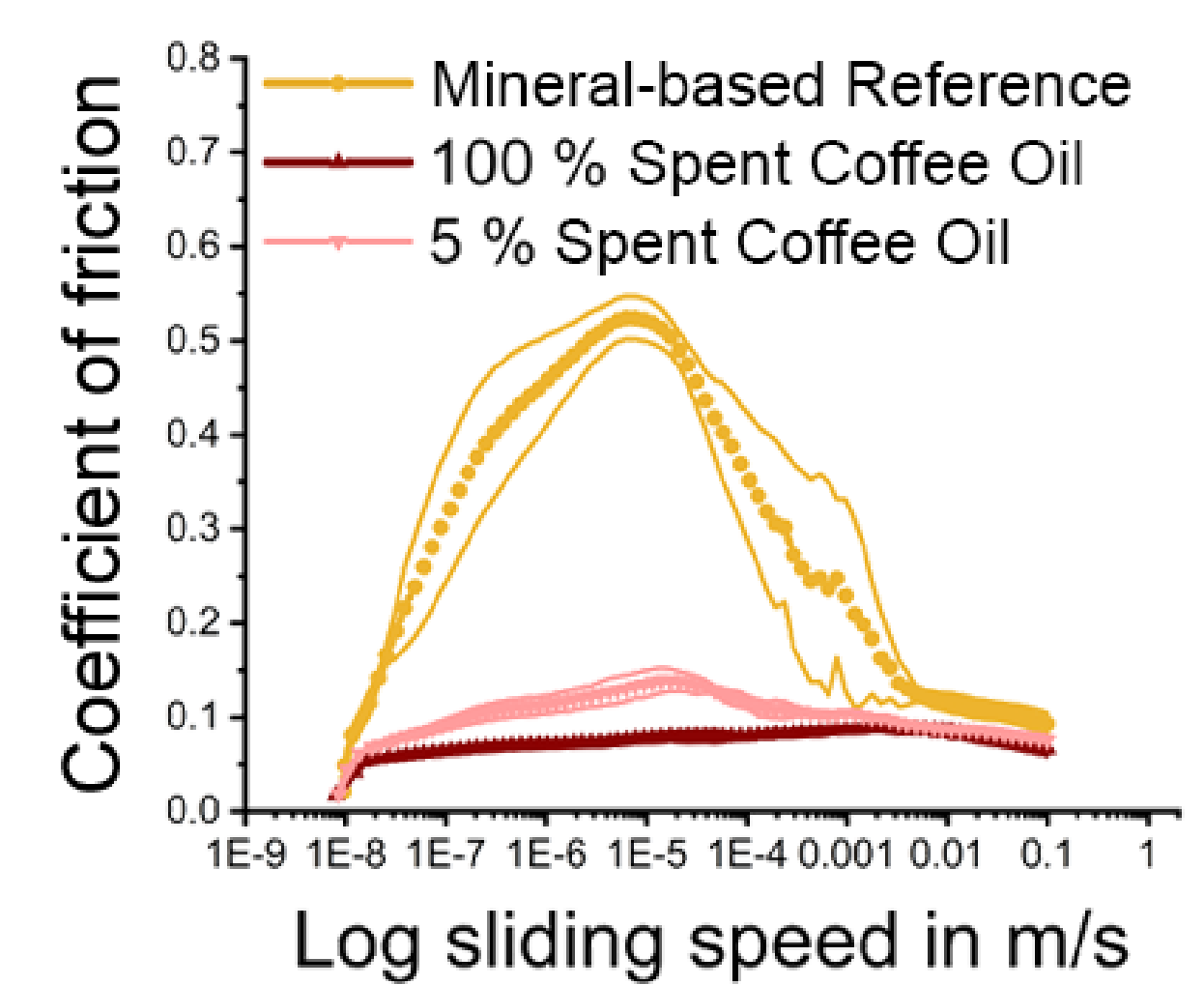
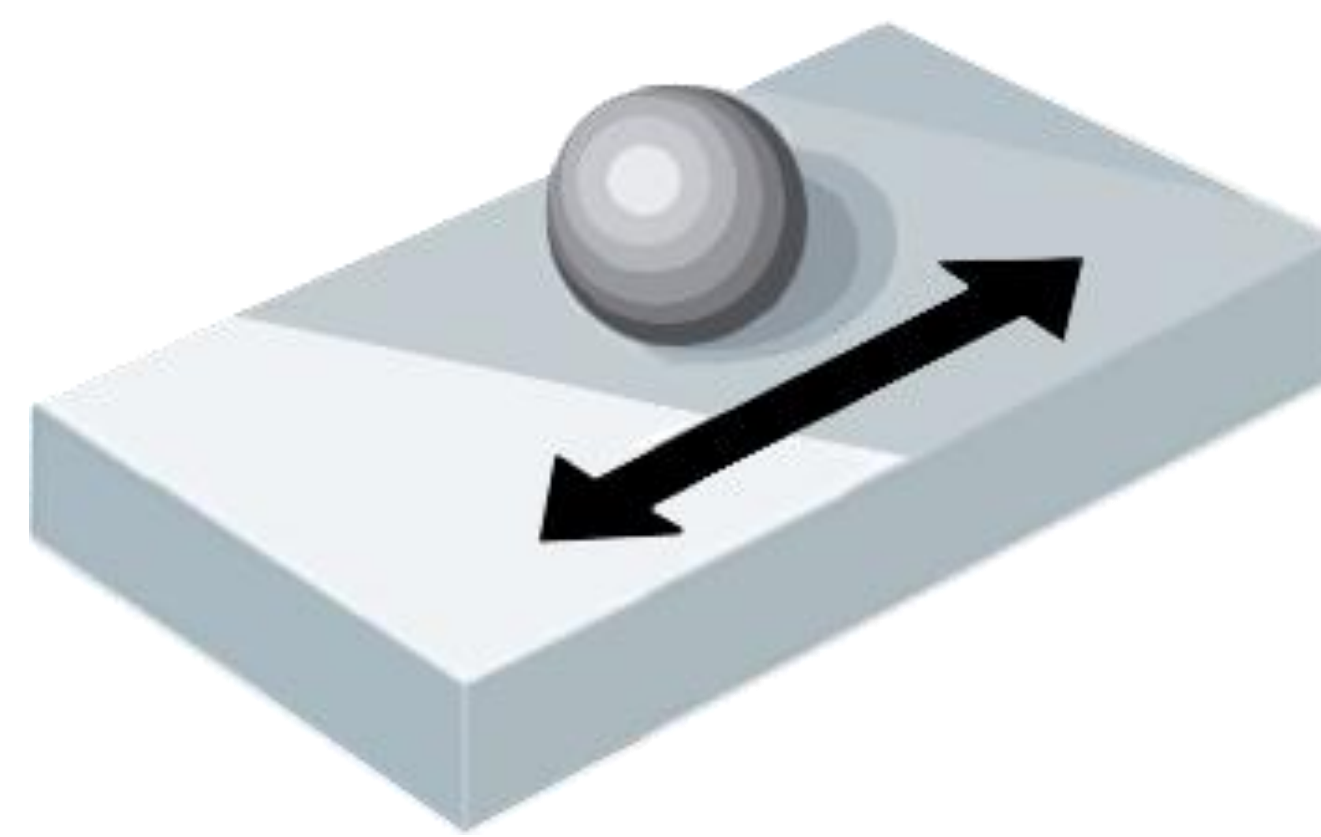
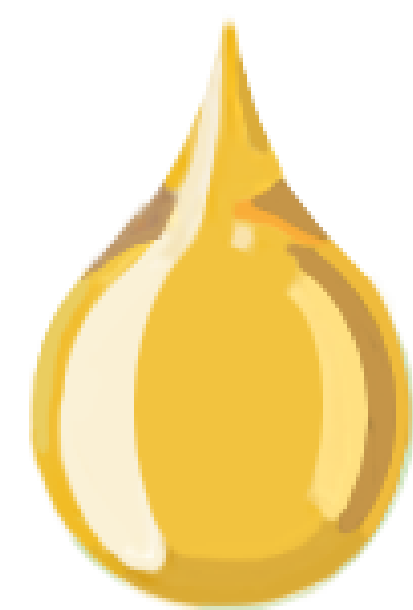


Figure: Excellent friction-reducing properties and a broad speed range with constant friction of spent coffee oil as lubricant base oil and a 5 wt% additive to a commercial mineral-based oil.

Within our work, **oil from spent coffee grounds** was extracted and investigated concerning its physicochemical and **tribological** properties as a possible sustainable substitution for common mineral-oil-based lubricant base oils or additives. The coffee grounds oil gave satisfying results concerning its ability to **reduce the coefficient of friction and wear** better than the chosen mineral-based oil reference. Moreover, although the chemistries of mineral oil (MO) and plant-based oil differ, the thermal stability of spent coffee grounds oil was at least comparable to the MO reference [2].

Sustainability approach

Concerning the UN Sustainable Development Goals (SDGs) [3], the proposed oil from spent coffee grounds complies to

- 2. **“Zero hunger”**: Coffee grounds oil is derived from waste and does not directly compete with the food industry (as other forms of sustainable oil sources do, e.g., vegetable oil-derived), so it helps to achieve food security.
- 12. **“Responsible consumption and production”**: Reducing waste from existing industrial processes reduces the material footprint, and using waste-derived, sustainable alternatives to mineral-based ones fights the global crisis even further.
- 13. **“Climate action”**: Replacing mineral-based sources with sustainable ones, such as spent coffee grounds, not only reduces GHG emissions but also prevents further progress of climate change.
- 14. & 15. **“Life below water”** and **“Life on land”**: Emissions to the environment (micro drops or oil mist) are less concerning from sustainable oils than hazardous mineral-based oils, which have a massively negative impact on land and water life [4].

Applications

Until now, there are just a few applications for spent coffee grounds, including coffee composites [5] or growing mushrooms [6].

- Europe has the **biggest coffee market** (32 % share) in the world [7].
- Market need for lubricant oils in Europe**: up to 280 kt/a synthetic and bio-lubricants and 4 Mt/a (93-95 % MO-based) lubricants total [8]. With 10 % recycling, ~50 kt/a of spent coffee oil can be produced [7].
- Lubricant additive, e.g., **friction modifier** or wear improver, to improve the properties of another base oil and replace non-environmentally friendly additives.
- Sustainable feedstock for **biodiesel production**.

Implementation

- Three-step process:
 - Collection (1) of spent coffee grounds from local cafés, coffee machines, and restaurants.
 - Drying (2) before further usage.
 - Extraction of the oil (3): Selected solvents and extraction methods (ultrasonic, microwave, Soxhlet, supercritical CO₂, ...) impact the sustainability of the overall process.
- Evaluation of upscaling feasibility of the extraction process from lab-scale to pilot-scale.
- Determination of the fully-formulated coffee-based lubricant shelf-life (stability), and biodegradability for the supposed field of application.

Benefits

- Promotion of the utilisation of **waste-derived**, sustainable natural sources and supporting the reduction/prevention of waste.
- Direct substitution of mineral-based oils supporting goals of global **decarbonisation**.
- The **local availability** of coffee grounds and, therefore, the possibility of the oil being produced in Austria, easy collection and extraction in good amounts make it a proper subject for industrial interest.



Literature

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