International Chemistry Tournament

9th Edition

PROBLEM SET

August 15-19, 2026

Korean Minjok Leadership Academy, Republic of Korea

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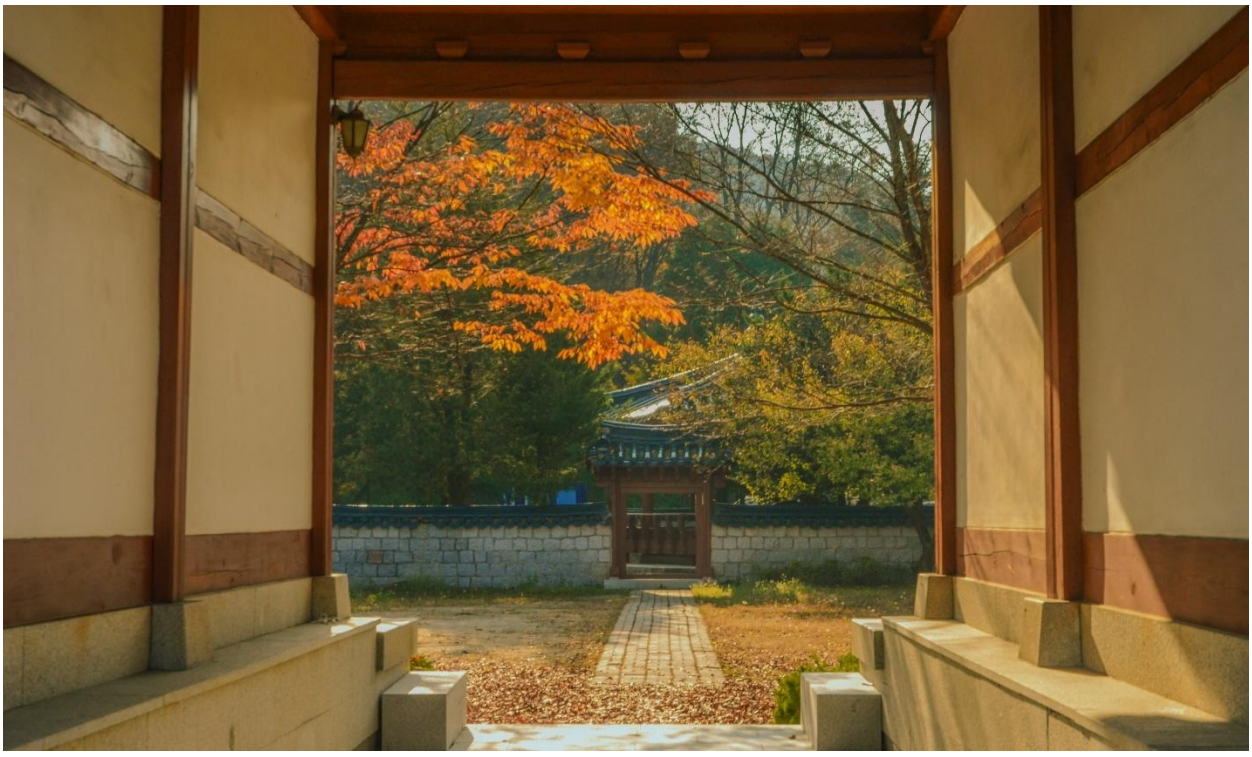


Problem 1. Coral glues

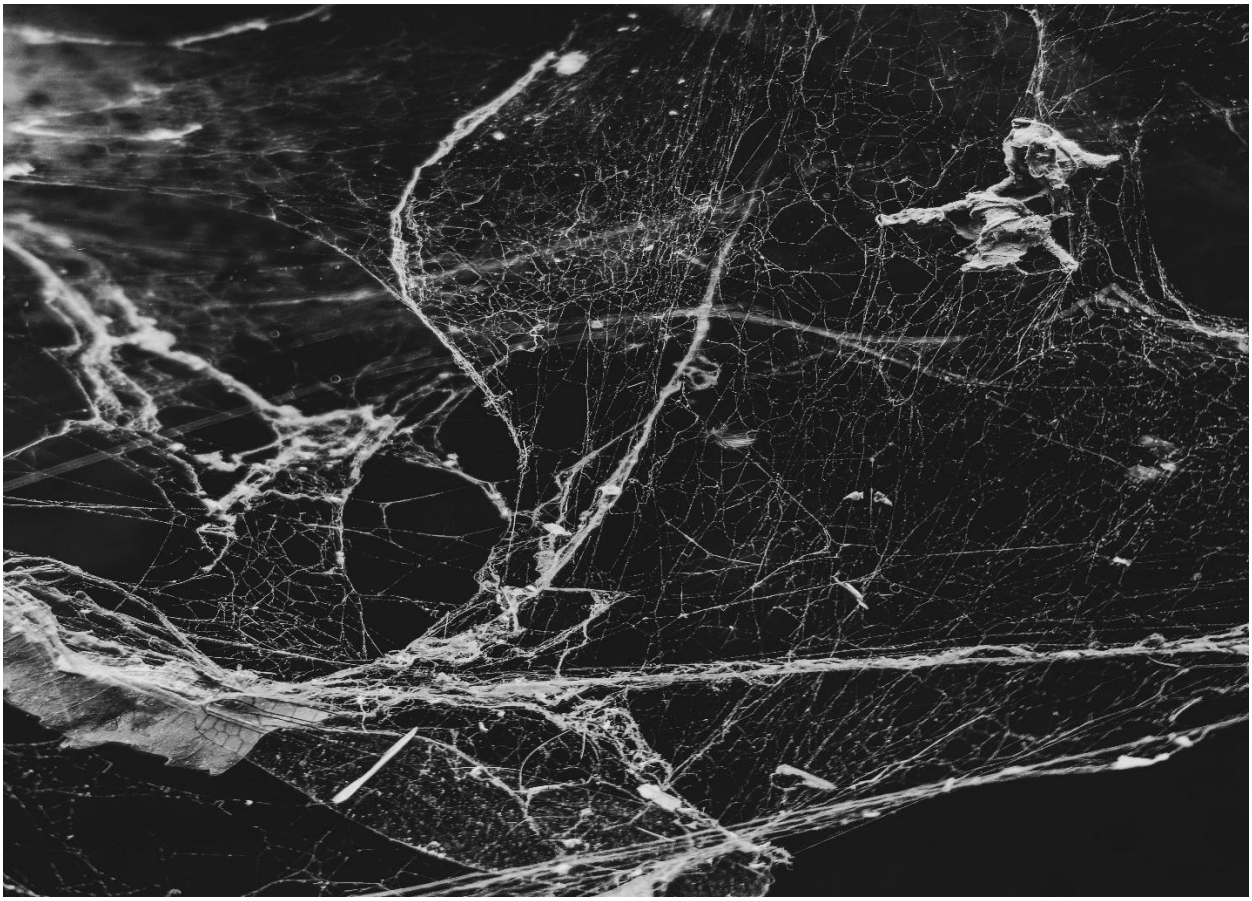
Adhesives join two surfaces by creating physical contact and forming attractive forces across the interface. Typical industrial adhesives rely on van der Waals forces, covalent bonding, hydrogen bonds, ionic interactions, or mechanical interlocking. Most common commercial glues are designed for dry conditions: they rely on solvent evaporation, moisture-triggered curing, or oxygen inhibition – mechanisms that fail or are slowed dramatically underwater.

Coral reefs are fragile and require rapid reattachment of fragments after storms or bleaching events. Design a non-toxic adhesive that can be applied directly in seawater to facilitate reattachment of coral fragments to calcium-carbonate surfaces, resisting salinity and dilution.

Problem 2. Revolution is not for the sane

Rhydonium is a fictional substance in the Star Wars universe that is used to power starships. In addition to its primary use as fuel, it also possesses multiple other special characteristics. It is described to be extremely unstable, producing explosions without a need for a spark. At the same time, it is also capable of inducing strong hallucinations in those who come into contact with it. While conventional fuels such as gasoline possess some of these characteristics, the effects are not even nearly as severe.

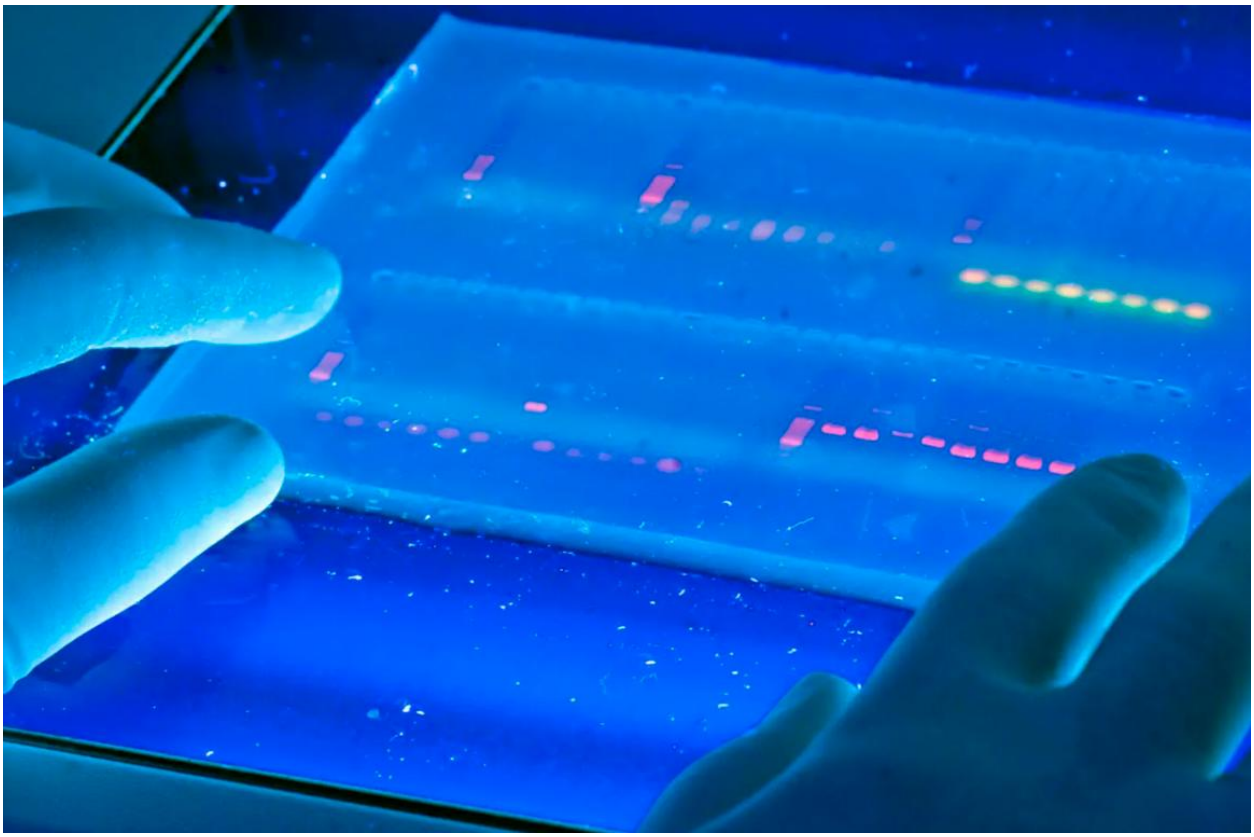
Propose a compound (or mixture of compounds) that matches the fictional description of rhydonium as closely as possible (instability, psychoactivity, and usage as fuel). How unstable is your proposed substance, and what is the chemical explanation for this? What precautions would you need to employ in order to use it as fuel? What is the reason for its psychoactive nature?



Problem 3. With great power comes great responsibility

Spider-man is one of the most popular comic book hero, with a friendly demeanor and a strong sense of justice. He's able to fight villains using his iconic webs, which allow him to swing from place to place and attach things to each other. This may sound fictional, but there are several materials which behave in a similar way, and it can also be possible to produce such webs at home.

Using only materials available in a typical household or school lab, propose a protocol that could be used to make webs like those of Spider-man, capable of extending across long distances, forming attachments to objects and surfaces, and being able to withstand significant amounts of load. Estimate how strong and durable would these spider-webs be and suggest a simple way to detach them.



Problem 4. Plates & Gels

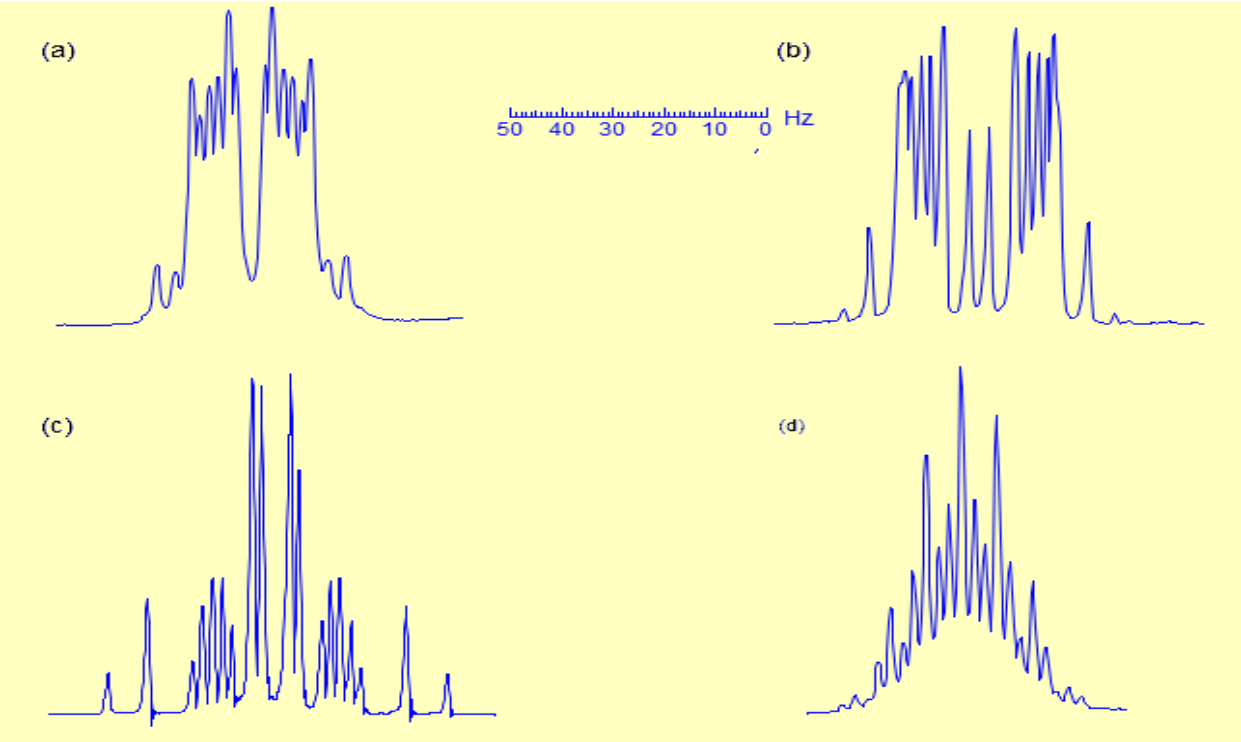
Thin layer chromatography (TLC) is one of the most commonly used techniques “to check a reactions completeness”, favoured by organic chemists around the world. It’s cheap, fast and applicable for many reactions. TLC, like all chromatography methods works by separating compounds by their different affinity towards the stationary and mobile phase, and this results in their differential movement compared to the solvent front, the ratio of the two is quantified as the retention factor. Biochemistry also uses several separation techniques such as classical chromatography-based ones but can also use electric fields to separate the materials in case of gel-electrophoresis techniques.

Could you imagine a classical organic chemistry synthesis (not involving any biological macromolecules) in which TLC could not be used to monitor the reaction’s progress, but gel electrophoresis is a viable alternative? How would you visualize and interpret your results?

Problem 5. Counter-counterfeiting

Counterfeiting has existed as long as currency existed, and it causes financial damage even nowadays. There are several measures built into modern banknotes, such as intricate patterns, special materials, and invisible signs, to make the act of copying the notes more difficult. Given the modern forms of these, one could think that anti-counterfeiting measures are a novelty of the 20th century, the practice is much older, for example this is the reason why coins have ridged edges. Counterfeiters and anti-counterfeiting measures are at a constant technological arms-race, as older technologies can be easily countered by emerging ones. This presents a special problem for currencies that have been used for a long time, such as the United States dollar, of which banknotes even as old as 1914 are accepted today.

Your task is to propose a method to incorporate a chemical signature to banknotes which can authenticate their printing series, in a way that is impossible or at least highly impractical to counterfeit. The signal must be reasonably simple to produce and read out, it must not rely on any pattern-based information, and it must be compatible with regular banknote usage.



Problem 6. Peakmaxxing

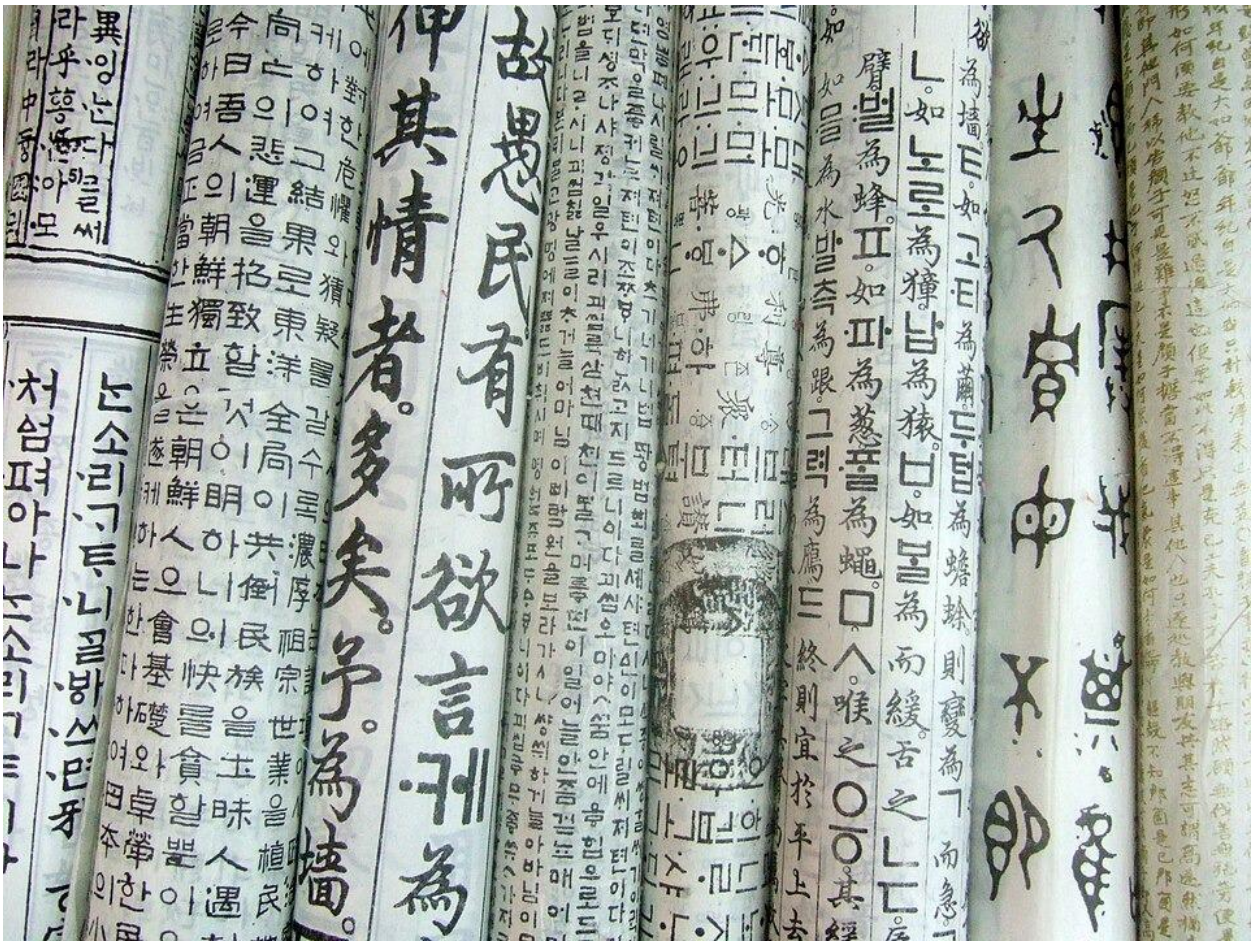
Nuclear magnetic resonance (NMR) spectroscopy is one of the most important and powerful analytical techniques that can be used to reveal the structure of molecules. Each NMR-active nucleus is represented by a peak in the spectrum, the chemical shift of which is indicative of its molecular environment. In these spectra, signals can be split into multiple subpeaks due to interactions with neighbouring nuclei, making the spectrum more complex. This can be undesirable in certain cases, for instance, 13C NMR is usually proton-decoupled to simplify the spectrum, allowing for easier interpretation. However, peak splitting patterns also reveal useful information about neighbouring nuclei.

An interesting exercise would be to think about what the practical limit is to peak splitting patterns. Propose a molecule where one of the nuclei has the highest possible peak multiplicity, while the sub-peaks are still possible to simultaneously resolve with a high-performance instrument. You may utilise any NMR-active nucleus, but your molecule must be sufficiently stable to record a spectrum with, and your solution must also include a synthesis for the molecule. Explain how the splitting pattern arises, with approximate coupling constants, and provide a justification as to why higher multiplicity is not possible to achieve.

Problem 7. Like Dissolves Like

The solubility of many substances can be rationalized using the “like dissolves like” principle: polar solvents tend to dissolve polar solutes, while non-polar solvents dissolve non-polar solutes; the reverse is usually not true. Surfactants are amphiphilic compounds that contain both polar and non-polar regions, which allows them to interact with both polar and non-polar environments. However, their solubility in either solvent is often limited, or they require the presence of a second phase to form micelles.

Propose an ionic compound (or a family of such compounds) that exhibits high solubility in both pure water and pure liquid alkanes (e.g., pentane or hexane). Explain the structural or chemical features that enable this unusual dual solubility and discuss any factors that might affect it. Propose a complete, plausible synthetic route for your compound(s), including reagents, reaction conditions, and purification methods.



Problem 8. Is Hanji the future of papers?

Traditional Korean paper, known as Hanji, is renowned for its exceptional durability. It has been reported to withstand rain without significant damage and can be preserved for centuries without special storage conditions, even under high humidity. Additionally, Hanji possesses notable thermal properties that once made it an effective insulator in traditional Korean homes, keeping interiors warm during winter and cool during summer. In contrast, most modern papers do not seem to be able to compete with Hanji. They have been optimized for mass production, often sacrificing long-term durability and environmental resistance in the process.

Your task will be to design a chemical process or treatment that could be integrated into modern paper manufacturing to make the resulting paper comparable in properties to Hanji (resistance, durability, heat conductivity), while remaining scalable and economically feasible for mass production.

Problem 9. Henna

Henna is a natural pigment derived from leaves of the plant Lawsonia inermis. Its use goes back eons, as it has been mentioned in sources dating back even to antiquity. Thus, it's not surprising that it has a widespread cultural use of several nations on multiple continents, often as part of wedding traditions.

It is commonly used as temporary body art, often likened to tattoos, which is achieved by the careful application of henna paste onto the skin. There henna creates an ever-darkening colour via an oxidative process, which reaches its maximum intensity over several days, and remains on the skin until the stained layer is slowly replaced by the body's natural processes.

Your task is to design a treatment that can speed up the darkening of the henna drawings on skin which would otherwise take days, quickly resulting in a dark colour instead of the initial reddish hues. Naturally, the process must not be harmful to people.

Problem 10. Contact Lenses

Contact lenses have transformed the optical medicine industry by providing a convenient alternative to wearing glasses for people with vision problems. Over time, their use has expanded beyond medical purposes, as modern lenses can also be produced in a wide range of colors and patterns for cosmetic enhancement. Despite these advantages, many contact lens wearers struggle with eye dryness when wearing lenses continuously for longer periods of time. Although eye drops and artificial tears can temporarily relieve the symptoms, their frequent application is not always convenient or practical during everyday activities.

Propose an improvement to contact lens design that enables safe and comfortable prolonged wear (at least 72 hours of continuous wear under normal daily activities) without causing or worsening dry-eye symptoms. The improved lenses must retain the essential functional features of conventional soft contact lenses (optical correction, comfort, oxygen transmissibility, fit) and be suitable for realistic manufacturing and consumer use.

Problem 11. Oh! There is a microplastic in my soup!

Every year, the concentration of micro- and nanoplastics is continuously increasing in the ocean, raising health concerns about the consumption of food derived from sea products since it could be contaminated with these particles. However, the development of techniques to reduce or even quantify micro- and nano plastics in complex matrices is still in the early stages.

Your task will be to choose a seafood-based soup or stew typical for your region and propose a chemical methodology to reduce the micro- and nanoplastics that it may contain. Explain the mechanism behind the reduction and evaluate the efficacy of your methodology. Consider that the flavor could be modified, but the food has to be edible after the procedure.

Problem 12. Save the Crunch

Potato chips (or crisps) are extremely popular snacks, consumed in all shapes, sizes, and flavours around the world, and part of what makes them so appealing is their crispiness. However, the chips quickly lose their crispiness when exposed to air due to moisture absorption. Manufacturers use packaging techniques like nitrogen flushing and moisture barriers, but once the bag is open, the contents must be consumed reasonably quickly, as the chips could go soggy in just a few days. It would be interesting to investigate how to reverse this process.

Your task is to propose a chemical treatment that is capable of restoring crispiness in soggy potato chips, without significantly raising or lowering the temperature during the process. The resulting chips must still be palatable and safe to consume.