



COFFEE

The fuel of materials research

Over the years that I've been involved in materials research, many people have discussed the topic of what drives materials research. Some rightfully discuss the influence of intellect and creativity. Others attribute progress to resources—money, equipment, facilities, staff. Others bend toward interdisciplinary work. It seems clear that all of these contribute in major ways.

What I haven't heard people discuss is coffee. Coffee is one of the major contributors toward progress in materials research. Without it, we are lost. Consider the morning, lunch, and afternoon coffee breaks at MRS Meetings. Huge urns of coffee are everywhere. It flows like water over Niagara Falls. It braces and invigorates us. Without it, our minds would dull, and our attention would wander. Some less sturdy souls would nod off. Our sense of community as materials researchers would vanish like a phantom in the night.

It has been estimated that humans drink 2,250,000,000 cups of coffee per day.¹ Given 16 standard cups to a gallon, that corresponds to 140,625,000 gallons of coffee every day. While this is not anywhere near the daily amount of water that flows over Niagara Falls,² it is an impressive number. Given what I see at MRS Meetings, I suspect that this average number spikes substantially during the weeklong run.

Like many of you, I have colleagues who are tethered to the coffee pot. They walk around all day each day with their coffee mug in their hands and indulge their habit. If you are what you eat and drink, then these materials researchers are 99.9% coffee bean.

My coffee habit started when I was a child. One night my family was having dinner with my Uncle John and his family. It was their habit to finish dinner with coffee. The aroma was wonderful, so I begged for some. To my surprise, my wish was granted. Of course, my "coffee" came with a liberal dose of cream and sugar, making the ratio of coffee minimal. Nonetheless, it was wonderful. Throughout my youth, this diluted concoction was my experience with coffee, although the amount of cream and sugar declined as I aged. At some point, I dropped the cream. More recently, I dropped the sugar. Even more recently, I switched to decaf.

This is how I start my mornings, with two cups of black decaffeinated coffee. While at home, I use my MRS mug that I obtained at a Fall Meeting many years ago. There is no telling how many thousands of gallons of coffee have passed through that mug.

In my youth, coffee was made in specialized metal pots through a percolation process.³ The bottom of the pot was filled with water. The coffee grounds were contained in a metal basket. Flame was applied to the bottom of the pot. The metal basket was porous so

that hot water could flow over the coffee grounds, and the coffee could flow out. Water was transported by the percolation process from a tube that went from the bottom of the pot through the metal basket. The water then flowed back through the metal basket and coffee grounds under the influence of gravity. Most of these pots had a glass port on top so that the percolation process could be monitored. The liquid in the pot would flow repeatedly through the basket, strengthening with each pass. As the water became coffee, the color of the liquid visible in the port would change. The observer could then decide when to interrupt the process.

Today, we have specialized electric coffee makers. Recently, some fancy (and expensive) systems have emerged to make this process as enjoyable as possible for the connoisseur of fine coffee. Many thousands of specialty coffee shops have opened in the last couple of decades, and many people visit them at all hours of the day and night to take advantage of the specialized coffees and coffee-based beverages (see a listing of terminology on the next page). They even serve regular coffee. One should note, though, that if you order regular coffee in such a shop, you might sense that you've committed some major faux pas or somehow become *déclassé*.

Just as materials researchers have benefited from coffee, the world coffee market has benefited from materials research. We've gone from a world with a relatively small variety of regular coffees, to one with a wide variety of coffees and coffee-based beverages. Processes for decaffeinating coffee were developed, along with ones for making instant coffee. Powdered forms of dairy and nondairy creamers were



made, and for those of us concerned about the svelteness of our figures, low calorie artificial sweeteners have been developed.

The paper filters used in modern coffee makers deserve special attention.⁴ They must be insoluble in water and coffee. They must be porous enough that coffee can flow through, but not so porous that grounds are lost. They must not contain any chemicals that would compromise the flavor of the coffee. I note that the Wiki article on filters contains the statement “Paper filters remove oily components called diterpenes; these organic compounds, present in unfiltered coffee, are known to be antimicrobial and anti-inflammatory. Metal or nylon mesh filters do not remove these components.”^{4,5} Also, the paper filters must be strong enough and stiff enough so that the walls don’t collapse during the coffee-making process. Otherwise, coffee grounds will flow into the pot. Most have crimped sidewalls that strengthen the filter and facilitate the flow of coffee through the sides into the pot below.

The first evidence of coffee consumption traces back to Ethiopia in the 11th century. By the 16th century, coffee drinking had spread throughout much of Africa, as well as much of Asia and Europe.⁶ Notable intellects who drank a lot of coffee include Beethoven, Bach, Benjamin Franklin, Voltaire, Søren Kierkegaard, Theodore Roosevelt, L. Frank Baum, Margaret Atwood, David Lynch, Marcel Proust, Gertrude Stein, Thomas Jefferson, Honoré de Balzac, Jean Paul Sartre, Bertrand Russell, and Albert Einstein.⁷⁻⁹

There are many quotes from notable people about the value of coffee.¹⁰ For example, “A mathematician is a device for turning coffee into theorems,” is variously attributed to Einstein, to the great mathematician Paul Erdős, and also to the great mathematician Alfréd Rényi.¹¹ Bertrand Russell purportedly stated, “Life is just one cup of coffee after another, and don’t look for anything else.” Sheik Abd al-Qadir purportedly said, “No one can understand the truth until he drinks of coffee’s frothy goodness.”

Given all that, is it too much to imagine that our scientific mythology is wrong? I imagine the young Isaac Newton wandering about on a beautiful day. He has just finished his breakfast, including his morning coffee, and is both invigorated and filled with a sense of comfort that allows his mind to comprehend aspects of nature that have never been imagined. He sees an apple tree, his mind, freed by the comfort of coffee from the cares and miseries of the world, expands to encompass an understanding of gravity, as well as what it means for the apple and all of nature.

Recent studies indicate that there are significant health benefits from drinking more coffee.¹² So when the MRS Fall and Spring Meetings open their doors, please partake of the coffee provided. Know that MRS is concerned enough about your health as well as your ability to fathom the essential truths and mysteries of materials research that they provide you with this wonderful beverage, truly the nectar of the gods, to ensure your health and facilitate your search for enlightenment.

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Essential research terminology

COLD DRIP COFFEE: Coffee grounds are soaked in cold water for approximately 12 hours, then strained. This is then used to make iced coffee with either milk or water.

CORTADO: Espresso topped with flat, steamed milk.

DRIP COFFEE: Coffee made with a filter, a press pot, or a traditional coffee maker. Flavor is produced when the coffee comes in contact with water.

ESPRESSO: Concentrated coffee made when hot water is forced at pressure through fine coffee grounds. The drink is traditionally two ounces total.

FILTER COFFEE: Drip coffee made with a ceramic, glass, or plastic cone lined with a paper filter.

FLAT WHITE: Espresso topped with flat, steamed milk.

FRENCH PRESS: Coffee made by soaking grounds with hot water in a vessel with a plunger and metal filter that pushes the grounds to the bottom.

LATTE: Espresso topped with steamed milk. The drink is traditionally eight ounces or more.

MACCHIATO: Espresso topped with just a bit of foamed steamed milk. The drink is served as two to three ounces total.

MOCHA: Espresso combined with chocolate and steamed milk.

REDEYE: A cup of brewed coffee with espresso.

RISTRETTO: Espresso pulled short (made with less water), which creates a more concentrated drink.



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