How Soap Works

How soap/surfactants and water removes soil from a surface.
By David Schauer

Whether soil particles are attached to carpet fibers, wood floors or restroom sinks, they need to be removed. But how is this done? Most of us wipe or scrub a dirty surface with soap and water without a second thought about how they actually work to remove soil.

The process of removing dirt begins at the molecular level. The removal of dirt by aqueous or water "baths" (water) is accomplished by: The wetting of the substrate (the surface to be cleaned) and the soil particles.

The adsorption of the surfactant (cleaning solution) and other bath components (such as inorganic ions) at the substrate/liquid and particle/liquid interfaces.

Starting With Water

Generally, a soil particle and substrate molecules are attracted to each other by their opposite electrical charges. Soil particle molecules may have a negative charge and the substrate molecules may have a positive charge. When water molecules come in contact with the substrate and particle molecules, the water molecules form electrical double layers between the soil particle and
substrate molecules.

The water molecules join with the substrate molecules and the soil-particle molecules and form different molecular structures (the electrical double layers). These new molecular structures almost always have similar electrical charges which repel each other, instead of combining with each other as
before.

The repelling factor comes from the change in the electrical charge of the new molecular structures. In other words, the water molecule and the substrate molecule join to form a new structure that we'll call the "A" molecule. Similarly, the water molecule and the soil-particle molecule join to form a
different new structure that we'll call the "B" molecule.

Almost always, the A and B molecules have similar electrical charges. Because of their similar charge, they repel each other instead of joining together. Contained within the new B molecules are the original soil particles, which are now removed from the substrate.

Also, water may cause the substrate surface to hydrate and swell (especially if the surface is made of a fibrous nature). The swelling can cause an actual physical distance between the soil-particle and substrate and aids in the cleaning process.

Adding a Surfactant

Although water alone can have a cleaning effect, it is often not sufficient, due to the fact that soil particles or the substrate surface often can be hydrophobic (water repelling). To more thoroughly wet a surface, a worker may need to spread the water and cleaning solution by hand or machine
(scrub). The need for scrubbing is then reduced by adsorption of a surfactant and other "bath" components at the substrate/liquid and particle/liquid interfaces.

Recall that with water alone, water molecules joined with the substrate and soil particle molecules to create molecules that repel each other. With a surfactant, however, the surfactant's molecules or other bath components (such as inorganic ions) adhere to the substrate and soil particle molecules,
creating new molecular compounds that replace their original bonds.

When the surfactant contacts the substrate/soil particle interface, the surfactant increases the negative electrical charge of the soil and the substrate by adhering to both surfaces. The substrate/soil particle bonds are actually replaced by the surfactant, which then creates new substrate/surfactant and soil particle/surfactant bonds.

With water alone, the new molecular structures repelled each other through electrical double layers. But when the surfactant bonds with the substrate, the surfactant takes the place of the existing bond with the soil particle molecule, and therefore separates the soil particle from the substrate, and
vice versa.

When the surfactant increases the negative electrical charge for the soil particle and substrate molecules, the surfactant actually overwhelms the soil particle and substrate molecules with extra electrons (negatively charged atoms [ions]). The surfactant gives the other molecules plenty of ions, eliminating the need for the soil particle and substrate molecules to join together to share their molecular structures.

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