Household Chemicals

* Cleaning agents
  + Soap
    - Sodium salt of a fatty acid
    - Originally made by cooking animal fat (triester of glycerol and three saturated fatty acids) with lye (NaOH); this digests the triester (adds three waters per fat molecule) forming sodium salts of three fatty acid conjugate base anions and one glycerol molecule from each fat molecule
    - Soap is amphipathic; each molecule has CO2– hydrophilic polar head group and long hydrophobic nonpolar hydrocarbon tail
    - Soap forms structures called micelles due to amphipathic property; these make spheres with head groups facing outward (forming outer surface of spheres interfaced with surrounding water molecules) and nonpolar tails in sphere centers which can dissolve nonpolar chemicals like grease and oil or skin oil containing “dirt”
    - Soap can kill bacteria by dissolving their amphipathic lipid bilayer membranes
    - Soap can form bubbles in air due to amphipathic property
      * These are hollow spheres with a bilayer of soap particles
      * Air is hydrophobic; soap tails are oriented toward both the outside and inside of bubbles
      * Hydrophilic head groups surround a thin film of water in the middle of a spherical bubble wall
  + Detergents
    - Detergents are amphipathic like soaps but the polar head groups are not carboxylate (CO2–) ions
      * Cationic surfactants are detergents with positively-charged cations rather than carboxylate as head groups
      * Anionic surfactants have negatively-charged head groups different than carboxylate groups
      * Nonionic surfactants have head groups which form multiple hydrogen bonds with water molecules but do not have charges (they are not ions)
      * Detergents make the same kinds of spherical structures that soaps do
      * Soaps form “soap scum” in hard water, but detergents do not
  + Drain cleaners
    - Strong acids or bases digest insoluble polymeric substances like proteins (ie. hair) by adding waters to break these down to water-soluble monomers; also strong base can turn insoluble fat into soluble soap
    - Enzyme-based drain cleaners digest more complicated organic chemicals which are not soluble in water and plug drains
    - Bacteria in drain cleaners can digest “biodegradable” organic chemicals (meaning organic chemicals which are edible by bacteria)
  + Antirust agents
    - Usually contain potassium oxalate
    - Potassium oxalate turns insoluble iron oxide (rust) into water-soluble potassium ferrioxalate
    - Sometimes antirust agents are strong acids which dissolve a layer of metal under the rust and thereby allow the rust to be rinsed away from the remaining metal
* Bleach
  + Is normally sodium hypochlorite, NaOCl, which is an oxidizing agent
  + NaOCl reacts with C=C double bonds in colored stains by breaking the double bonds and replacing each with two single bonds to OH, resulting in colorless reaction products; the staining chemical becomes colorless
  + Occasionally bleach is sodium borate (Na3BO3) rather than NaClO; sodium borate is a milder oxidizing agent than NaClO
  + NaClO is very strong; if it is not diluted (ie. straight Chlorox) it will eat holes in clothes and bleach the color out of colored clothing
* Water softeners
  + Chelating agents like EDTA surround insoluble hard water ions like Mg2+ and Ca2+ in soap scum or bathtub rings at the particle level to form water-soluble anions
  + Phosphates and carbonates precipitate hard metal cations which are then removed by passing the treated water through a filter, leaving metal precipitates behind
  + Ion exchange resins are polymers containing multiple anionic (negatively-charged) groups bonded to these polymers which bind to (positive) metal cations (removing them from water) when hard water is run through cartridges containing these ion-exchange resins
* Solvents
  + Paint thinners are usually hydrocarbons like lighter fluid obtained from cracking and distilling petroleum
    - Often called petroleum distillates
    - Can be used to remove oil-based paint from brushes
    - Are hydrophobic; can dissolve grease, but are not water-soluble
    - Good for removing tree sap on windshields
    - Anesthetic and mildly toxic if inhaled
    - Very flammable
  + Linseed oil is the medium often used in oil-based paints
    - Can also be used as an oil-based paint remover
    - Not as volatile as petroleum distillates; will probably eventually need to be removed from brushes with petroleum distillates
    - Is a triester of glycerol, essentially an unsaturated fat obtained from flaxseed
  + Nail polish removers
    - Generally acetone or ethyl acetate
    - Neither very toxic, but acetone less toxic than ethyl acetate
    - Acetone both water and oil soluble
    - Ethyl acetate less water soluble than acetone
* Paint
  + Comes in two forms: water-based and oil-based
    - Oil-based paint is hydrophobic
      * Won’t mix with water
      * Generally is suspended in an oil like linseed oil
      * Is harder to clean up than water-based paints
      * Paint thinners used to clean brushes are technically hazardous waste; legal disposal is somewhat difficult
    - Water-based paints are generally suspension of pigment mixed with latex and water
      * Latex is microscopic rubber particles
      * Water-based paints can be easily cleaned up with water and/or soap
      * Cleanup liquids can be washed down sink drains
  + Pigments are either organic or inorganic chemicals
    - Organic chemicals usually contain aromatic rings and/or double bonds
      * Aromatic rings and/or double bonds which are adjacent to one another enable electron delocalization
      * Delocalized electrons absorb and scatter visible (ie. colored) light
    - Inorganic pigments usually contain transition metals
      * Transition metal chemicals are normally colored
      * Electrons in transition metals generally can easily gain or lose energy by absorbing or scattering colored light like delocalized electrons in organic pigments
      * White paint pigment used to be lead oxide
        + Lead oxide is very toxic
        + Titanium oxide is now used instead of lead oxide in white paint due to toxicity of lead

Beach sand in some places in Australia, Africa, India, and China is mostly titanium dioxide

Beach sand in other places is silicon dioxide

Titanium dioxide makes a better white paint pigment than silicon dioxide

* + - * + Old buildings in inner cities may still contain lead paint

Lead has a sweet taste and children will often find and eat lead paint chips

Children eating lead paint chips was once the major source of lead poisoning

* Wax is long-chain (fatty acid) monoesters (made from simple alcohols rather than glycerol)
* Glue
  + Hot glue is basically a thermoplastic (low-melting) polymer (plastic)
  + Solvent-based glue works like paint; solvent evaporates leaving behind a solid polymer (plastic)
  + Superglue is ethyl cyanoacrylate monomer; water vapor in the air initiates a polymerization reaction
  + Binary glue like epoxy glue works by mixing a resin and a hardener
    - Resin is a monomer with two epoxide functional groups which do bond-forming condensation reactions with amine groups (with loss of waters)
    - Hardener is monomer containing 3 or 4 amine groups which forms crosslinked polymer when reacted with resin
* Personal care products
  + Moisturizing lotion contains lipids
    - Phospholipids repair damaged cell membranes
    - Repaired cell membranes keep cells from leaking contents, dying, and drying out
    - Lipids also prevent skin oil loss from skin, giving it a “dry” (nonlubricated) feel and appearance
  + Exfoliants loosen dead skin so that it scruffs off easily
  + Lipstick is wax (fatty acid monoesters) mixed with colored dye
  + Sunscreen contains aromatic rings conjugated with (attached to) carbonyl groups which absorb hazardous UV light along with TiO2 and ZnO which reflect UV light
  + Self-tanning products contain the sugar erythulose and sometimes also dihydroxyacetone
    - Erythulose in a monosaccharide (sugar monomer) found in raspberries
    - Self-tanning (sunless tanning) products actually produce chemical pigmentation in the skin by causing it to produce more melanin
    - This occurs because erythulose causes skin to produce AGEs (advanced glycation endproducts) which causes melanocytes to produce more melanin pigment than normal
    - DHA (dihydroxyacetone) sometimes improves the look of a self tan; it makes the tan last longer by slowing down the body’s metabolism of AGEs
    - AGEs sensitize the skin to UV damage from the sun; it is recommended that you need to stay out of the sun or wear an extremely high-SPF sunblock for 24 hours after applying a self-tanning product
  + Glycerol (obtained from fat or generated by organic synthesis) found in cosmetics and shaving cream lubricates skin
  + Deodorants and antiperspirants
    - Technically not the same things
    - Deodorants contain germicide disinfectants which kill odor-causing bacteria; these live on (consume) sweat
    - Antiperspirants contain chemicals like aluminum chlorhydrate, Al2(OH)5Cl⋅2H2O, which plugs up sweat glands and prevents sweat from leaking out onto the surface of the skin
  + Toothpaste
    - Needs to minimize biofilm (plaque-causing bacteria) and repair microfissures caused by release of acids by these bacteria
      * Biofilm bacteria
        + One approach to biofilm issue was to include the antibiotic triclosan in toothpaste (Colgate); this has now been prohibited because triclosan is an endocrine (hormone) disruptor (unhealthy)
        + Another approach to minimize biofilm is hydrogen peroxide; some toothpastes use this
        + Fluoride is bacteriocidic and strengthens tooth enamel against development of microfissures
        + Fluoride also kills healthy mouth bacteria
        + Titanium dioxide (TiO2), an abrasive, scrapes tartar off of teeth; this also wears down tooth enamel though
* Classical approach to managing microfissures is to use fluoride
  + Tooth enamel is calcium hydroxyapatite (Ca5(PO4)3OH)
  + Fluoride turns calcium hydroxyapatite into calcium fluorophosphate (Ca5(PO4)3F) which is more resistant to acid damage than calcium hydroxyapatite
    - * Another approach to handling microfissures is to use tin(II), (stannous fluoride); this replaces Ca2+ in teeth and also makes teeth more resistant to microfissure formation
      * The newest microfissure management technology involves adding nanohydroxyapatite particles to toothpaste; these are small enough to fit into microfissures and repair them with actual tooth material
  + Hair
    - Curlers and straighteners make or break disulfide bridges (4° protein structures) that shape strands of hair
      * HSCH2CO2H breaks links to allow hair to be reshaped
      * Hydrogen peroxide makes new links after hair is reshaped
    - Hairspray is a solvent-based polymer; it essentially glues hairs together in a particular way
    - Dyes are usually organic water-soluble colored chemicals (contain conjugated double bonds and aromatic rings) which adhere to proteins (ie. hair)
      * “Permanent” dyes are mixed with ammonia (NH3)
      * Ammonia opens up the cuticle (outer layer of hair strands) to allow dye to penetrate
      * Non-permanent dyes do not contain ammonia; they can be washed out of hair with shampoo
    - Shampoo is basically just mild detergent concentrate suspended in water
* Toxicity
  + Bleach plus ammonia: 3 NH3 + 3 NaOCl → NH2Cl (chloramine) + NH2NH2 (hydrazine) + 3 NaOH
    - Chloramine is corrosive and metabolic toxin
    - Hydrazine is a mild carcinogen
    - Don’t mix bleach and ammonia
* Bleach plus acid: NaOCl + HCl → NaOH + Cl2
  + Cl2 is a corrosive toxin; was once used as a war gas
  + Cl2 causes pulmonary edema (fluid buildup due to lung damage)
  + Bleach alone releases some Cl2
* Petroleum distillates (paint thinner, lighter fluid, etc.) are hydrocarbons
  + Lipids in cell membranes have hydrophobic tails which are soluble in hydrocarbons (hydrocarbons break up cell membranes)
  + Hydrocarbons inhaled get into bloodstream
  + Hydrocarbons in bloodstream carried to and damage cells in multiple organs
  + Hydrocarbons cross blood-brain barrier, get into brain; this can cause euphoria and/or brain damage
* Insecticides, rodent poison, etc. tend to be metabolic toxins