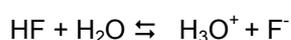

Teacher Notes

Brushing up on chemistry

The basic ingredients of toothpastes

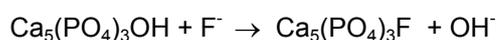
While the exact formula of each brand of toothpaste is proprietary, most toothpaste contain the same basic ingredients. These include:

Fluoride: Perhaps the most important toothpaste ingredient is fluoride. Fluoride incorporates itself into tooth enamel making your teeth more resistant to acids produced by plaque bacteria, as well as acids found in fruit juices, soda (both regular and diet) and certain foods. Sodium fluoride (NaF), stannous fluoride (SnCl₂), and sodium monofluorophosphate (Na₂PO₃F) are common sources of fluoride used. The monofluorophosphate ion produces fluoride ions through a hydrolysis reaction (Muhler, 1980):



(Note: The various phosphoric anions, H₂PO₄⁻, HPO₄²⁻, and PO₄³⁻ also exist in equilibrium.)

Fluoride ion acts on the basic component of enamel, hydroxyapatite, Ca₅(PO₄)₃OH, by replacing the hydroxide ion OH⁻. In this way, hydroxyapatite is replaced partially by the *harder* fluoro analogue fluoroapatite (Banks, 1990):



Stannous fluoride has the added advantage over sodium fluoride and sodium monofluorophosphate in that the tin (II) reacts with carious and precarious enamel. For more information about fluoride and dental health, the reader is referred to the book by Muhler and Hine (1959).

Abrasives: Abrasives give toothpaste its cleaning power. They remove stains and plaque, as well as polish teeth. Common abrasives include calcium phosphates, alumina, calcium carbonate, and silica. Toothpaste should be abrasive enough to remove plaque and stains, but not abrasive enough to damage tooth enamel.

Detergents: Detergents create the foaming action we associate with toothpastes. Foam keeps the toothpaste in our mouths, preventing it from dribbling out as we brush. SLS (sodium lauryl sulfate) is the detergent most commonly used. Unfortunately, SLS and other detergents have been linked to the promotion of canker sores (mouth ulcers) in susceptible individuals. The presence of bad tasting detergents requires the use of strong flavorings to mask the bad taste.

Humectants: Humectants give toothpaste its texture as well as retain moisture so that your toothpaste does not dry out. Glycerine, sorbitol, and water are common humectants. Xylitol is an uncommon, but superior humectant, which also boosts fluoride's cavity fighting power.

Thickeners: Thickeners also help to create the texture of toothpaste and determine how 'thick' your toothpaste is. Carrageenan, cellulose gum, and xanthan gum are common thickening agents.

Preservatives: Preservatives prevent the growth of micro-organisms in toothpaste. This eliminates the need to refrigerate toothpaste. Common preservatives include sodium benzoate, methyl paraben, and ethyl paraben.

Flavoring Agents: These are added to improve the taste of toothpaste. You may have noticed that toothpastes often have very strong flavouring. This is necessary to cover up the horrid taste of most detergents, especially SLS.

Sweeteners: Sweeteners also improve the taste of toothpaste. Most toothpaste sweeteners are artificial and contribute very little to cavity formation. Saccharin is a common toothpaste sweetener.

Coloring Agents: Some toothpastes would look down right disgusting if it were not for colouring agents. Colouring agents provide toothpaste with pleasing colours. Artificial dyes are used to make red, green, and blue toothpastes. Titanium dioxide is used to make some toothpastes white.

More information can be found at the following web addresses (accessed 3 August 2007):

<http://www.dentalhealth.ie/dentalhealth/index.tpl?secid=20020821120259&subid=20020822145621>

<http://www.drBunn.com/tthpste.htm>

<http://www.saveyoursmile.com/toothpaste/toothpaste-a.html>

(a continues as b, c...)

Typical compounds in fluoride dentifrices (toothpastes)

(from: Newbrun, 1972)

Type of compound	Compound (%) in dentifrice		
	<i>Brand A</i>	<i>Brand B</i>	<i>Brand C</i>
<i>Therapeutic</i>	SnF ₂ (0.40)	Na ₂ PO ₃ F (0.76)	NaF (0.21)
<i>Abrasive</i>	Ca ₂ P ₂ O ₇ (39) Sn ₂ P ₂ O ₇ (1)	(NaPO ₃) _x (41.8) CaHPO ₄ (5.0)	Ca ₂ P ₂ O ₇ (40)
<i>Humectant</i>	Glycerol (10) Sorbitol (20)	Glycerol (12.8) Sorbitol (14)	Sorbitol (30)
<i>Water</i>	(25)	(21.1)	(26.1)
<i>Detergents</i>	(4.6)	Sodium lauryl sulfate (1.5)	Sodium monoglycerol sulfonate & sodium alkyl sulfate (1.0)
<i>Miscellaneous</i>	--	-- (4.00)	-- (2.7)

Ένα πρόσφατο πολύ ενδιαφέρον άρθρο αναφέρεται στις φθοριούχες οδοντόκρεμες A recent article refers to fluoride in toothpastes (Rakita, 2004). We provide below some information from this article.

What Is Fluoride?

As the 17th most abundant element in the Earth's crust, fluorine, in the form of the fluoride ion,

Developers: Georgios Tsaparlis and Georgios Papaphotis

Institution: Department of Chemistry, University of Ioannina

Country: Greece

occurs naturally in all water sources, including the oceans. Fluoride used for dental applications is available from two major sources: products containing fluoride in their formulations (topical)

and fluorides that are ingested into the body from treated water and other sources (systemic). Topical fluorides strengthen teeth already present in the mouth, making them more decay resistant. Topical fluorides include toothpastes, mouth rinses, and professionally applied fluoride therapies. The significant drop in the level of cavities since 1960 is attributed to the widespread public acceptance of fluoride-containing toothpastes. Other sources of self-applied fluoride are mouth rinses available over the counter and by prescription. The ADA recommends the use of fluoride rinses, but discourages use by children under age six because they may swallow the rinse.

Dentists and dental hygienists may give patients fluoride treatments as part of routine dental care. The fluorides added to professionally applied gels, foams, and rinses are more concentrated than those in self-applied fluoride sources, and therefore are not needed as frequently.

Fluoride is typically added to a self-applied dentifrice formulation at the level of about 1000 ppm, even in areas where the water supply is fluoridated. Because the fluoride additives are considered active ingredients, the FDA regulates their presence in toothpaste in the United States. Currently, the FDA permits the use of three sources of fluoride: sodium fluoride, stannous fluoride, and sodium monofluorophosphate. To be used in dental care products (toothpaste, mouthwash, and professionally applied topical fluoride treatments), the compounds must be made to U.S. Pharmacopoeia standards. Producers of USP-grade fluorides are regularly inspected and reviewed by the FDA (12, 13).

A Brief History of Toothpaste and Toothbrushes

Toothpaste and toothbrushes have been around for centuries. Toothpaste was used as long ago as 500 B.C.E. in China and India. Modern toothpastes were developed in the 1800s and improvements followed quickly. A dentist called Peabody was the first to add soap to toothpaste in 1824. John Harris added chalk as an additive to toothpaste in the 1850s. In 1873, Colgate mass-produced pleasant smelling toothpaste in a jar. In 1892, Washington Sheffield of Connecticut first put toothpaste into a collapsible tube, called Dr. Sheffield's Creme Dentifrice. By 1896, Colgate Dental Cream was packaged in collapsible tubes. Advancements in synthetic

detergents (after World War II) replaced the soap used in toothpaste with emulsifying agents such as sodium lauryl sulfate and sodium ricinoleate.

Toothbrushes, too, have a long history. Early civilizations cleaned their teeth with pig bristles. Ancient Chinese invented natural bristle brushes. French dentists promoted the European use of toothbrushes in the 17th and early 18th centuries. The first mass-produced toothbrush was made by William Addis of Clerkenwald, England. The first American to patent a toothbrush was H. N. Wadsworth and companies began to mass-produce toothbrushes in America around 1885. The Florence Manufacturing Company of Massachusetts made an early American toothbrush, the Pro-phy-lac-tic brush, and was also the first company to sell toothbrushes packaged in boxes.

The first nylon bristle brushes were introduced in 1938. In 1939 the first real electric toothbrush was developed in Switzerland. Squibb first marketed the electrical toothbrush in the United States in 1960, called the Broxodent. General Electric introduced rechargeable cordless toothbrush in 1961. Interplak was the first rotary action electrical tooth-brush for home use, introduced in 1987.

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Rakita P.E. (2004). Rakita Dentifrice Fluoride. *Journal of Chemical Education*, 81, 677-680.