"TOOTH" INFINITY.... AND BEYOND!

Tooth enamel is a layer (approximately 2mm in depth) of a chemical called hydroxyapatite: Ca10(PO4)6(**OH**)2(s) - the hardest substance in the body. (Do you recall the mineral "apatite" from the Moh's Scale of Hardness in Earth Science…?) As you know, your teeth can decay, and the chief cause of tooth decay is due to demineralization of the hydroxyapatite (hi-drox-e-ap-a-tite). The demineralization of the enamel is a complex cycle which impinges upon the fields of biology and chemistry, especially acid/base theory. There is good news though. Using acid/base theory and a replacement reaction you can inhibit the process of demineralization.

The demineralization of tooth enamel begins with the presence of one



strain of bacteria that makes plaque as a by-product of its life cycle. Plaque

is a thin sugary adhesive material. A ***second strain*** of bacteria,

*Streptococcus mutans,* lives off this plaque and produces a weak acid

called lactic acid (C3H6O3 or CH3CH(OH)COOH). This lactic acid

is the real problem. [Buell & Girard, Wilbraham et. al]

Your saliva plays an important role by keeping the plaque at a pH 6.8.

However, when the presence of lactic acid lowers the pH of plaque to 5.5 or

less, the benefit of saliva is lost, and the tooth enamel can begin to break

down. [Wilbraham et. al.]

One of the reactions associated with demineralization is:

Ca10(PO4)6(**OH**)2(s) + CH3CH(OH)COO**H**(aq) → 10 Ca+2(aq) + 6 PO4-3(aq) + H2O(l) + CH3CH(OH)COO-1(aq)

**⮱ ⮰**  **⮱** lost by the enamel **⮱**becomes soluble and

(OH)-1 reacts with the "acidic" H+1 dissolves away

creating a soluble salt (demineralization)

Once the enamel is penetrated, dental caries, or cavities, result. The damage can progress to the underlying dentin and pulp, which contains blood vessels and nerves, and can cause a toothache. (Buell & Girard)

You can control the "kinetics" (the rate) of tooth decay by removing one of the initial reactants, such as the plaque. This is done normally by removing the plaque with a cleaner and an abrasive (toothpaste). The nice thing about toothpaste is that at the same time you can strengthen the enamel. The toothpaste acts as the "cleaner and abrasive" as well as the delivery system for a reactant needed for the strengthening process. (Buell & Girard, Consumer Reports)

Fluoride (the reduced form of fluorine) is that needed reactant. Most toothpastes contain a compound of fluoride (often, NaF) and it is the fluoride ion (F1-) that is important. It's deposition into the tooth enamel strengthens the enamel by converting the hydroxyapatite into fluorapatite (flor-ap-atite). One of the reactions associated with ***strengthening the enamel*** is:

Ca10(PO4)6(**OH**)2(aq) + 2 NaF(aq) → Ca10(PO4)6F2(s) + 2 Na+1(aq) + 2 OH-1(aq)

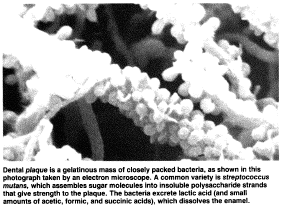
⮱ hydroxyapatite ⮱from ⮱ fluorapatite

toothpaste

Fluorapatite is denser and harder than hydroxyapatite. The presence of the fluoride ion even suppresses the

ability of  *S. mutans* to generate acid. However, the more important bonus is that fluorapatite, is **100 times more resistant to the attacks of acids than hydroxyapatite!** (Buell & Girard)

Since most Americans spend fewer than 60 seconds brushing their teeth the challenge for toothpaste manufacturers has been to create "super-efficient / super-fast" fluoride delivery systems. Some toothpastes are better than others at the delivery process. (Consumer Reports)



**As an aside:**

Do you ever experience that bitter taste of orange juice, right after you brushed your teeth? Well, I do…and so does 66% of the U.S. population. In truth it may be another one of those pesky genetic issues. (DeCristofaro)

First, you must understand the "flavor" is a complex interaction, between taste (sour, bitter, sweet, salty) and smell (the aroma of food) and this interaction is mediated by your brain.

Taste begins with an ion or molecule docking in a receptor on the tongue or palate (kind of like that old lock & key idea for enzymes). The substances that trigger sweet and bitter tastes are usually large, complex organic molecules. It's just the opposite for salty and sour tastes. These are triggered by cations. (DeCristofaro)

Secondly, with respect to the taste of "bitterness", you need to realize that many of us have receptors for bitterness while some do not. These receptors may be controlled by various genes (DNA). If you have two genes for the receptors… you probably have many "bitterness" receptors. With one gene your bitterness receptors are fewer. No genes for this trait and you *might* have a tough time finding any receptors for detecting bitter taste. (DeCristofaro)

Now take a look at toothpaste. Sodium lauryl sulfate is the detergent (soap) found in toothpaste. (Buell & Girard, De Cristofaro) It also **suppresses** some receptors and **sensitizes** other the taste receptors. When you brush your teeth, the sodium lauryl sulfate goes to work on each of us, somewhat differently. One study found that the citric acid (found in orange juice) has its bitterness enhanced by about 10 times due to the sensitizing activity of sodium laurly sulfate! (DeCristofaro)

Thus, it seems to be the sodium lauryl sulfate of toothpaste which enhances a genetic pre-disposition towards detecting bitterness as you drink that morning orange juice.

How can you solve the problem? For one, don't drink orange juice right after brushing your teeth. Give a rest period of 20 minutes to 30 minutes in between the two activities.

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An adaptation of information from:

Buell and Girard. Chemistry: An Environmental Perspective; Prentice Hall 1994 p 82

DeCristofaro. Chemmatters April 1995 p 14

Wilbraham et al. Chemistry; Addison-Wesley 2002 p603

Consumer Reports