from-A Flavor-Receptor Ellipsoid Model for the Prediction of Flavor Sensory Thresholds

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Threshold Energies

The threshold value can best be viewed as a response to a stimulus. The stimulus is the concentration of the flavor in a liquid. (Liquid threshold values will be considered for the rest of this report). The response is the ability of the individual to sense the flavor molecule, which means that some positive interaction has occurred with his/her receptors. The receptors of interest are olfactory receptors (OR).

It is sometimes viewed that some minimal energy is required for a minimal response. This indicates that the concentration of a flavor chemical in solution must by some means provide an "energy" to produce a response. Energy can be mechanical, heat, chemical, light, nuclear, or electrical. Since most flavors do not emit radiation either nuclear or electromagnetic, light and nuclear energy are not involved. Most flavor components are organic and electrically neutral so electrical and magnetic energy are probably not involved. This leaves mechanical, chemical, and heat energy as potential stimuli. In the case of smell, little is known about chemical reactions that occur with receptors. Reaction products are not usually considered the consequence of the sense of smell. For the other senses (vision, hearing, taste, touch) chemical reaction is not considered to be the primary stimulus. The secondary reactions such as binding of GTP to protein receptors, which occur with the bitter sense and in the retina, are chemical interactions. Presently, it will be assumed that either a mechanical and/or heat energy mechanism is necessary as the primary stimulus to an olfactory receptor.

Several types of mechanical energy mechanisms can be responsible for primary receptor interaction. The flavor molecule can be viewed as a particle composed of various atoms. The atoms are held together in a particular configuration with chemical bonds (C-C, C-O, O-H, etc.). As the molecule travels either in the liquid of gas state, it carries energy due to its translational motion in space, its rotation in space, and its internal (vibrational) energy. The interaction of the molecule with the receptor is viewed as:

a. Impact of the molecule with a receptor molecule and transfer of energy.

b. "Docking" of a flavor molecule and transfer of translational, rotational and/ or vibrational energy.

c. Conversion of a molecular potential energy to an interaction energy with the receptor.

The potential energy of a molecule can be viewed as an interaction of the "energy fields" of the flavor molecule and receptor. The energy field is related to what are labeled hydrophilic and hydrophobic interactions of a molecule. The nature of these interactions will be discussed below.

Another type of energy is PV work that is due to expansion and compression of gas. Minute pressure and volume changes occur in the nasal passage similar to pressure changes, which occur in the auditory canal and are sensed as sound pressure waves. Similar waves can occur during the vaporization of liquid and the expansion of vapors in the nasal passage. This energy can be transferred to receptors like the transfer of sound energy to the vibrational modes of the eardrum.

Expansion of vapor can occur either isothermally (constant temperature) or adiabatically (constant heat). The heat involved in vaporization is the enthalpy of vaporization of water and flavors. Other heats involve the enthalpy of interaction of flavors with hydrophobic and hydrophilic sites on the receptor. The temperature within the nasal passage can be assumed to be constant, although this may not be entirely true as heat is exchanged between the liquid and nasal cavity depending on whether the liquid temperature is above or below 98.6 ^{o}F.

Next: Concept of Threshold Force