Overview

The importance of surface tension in industry

Surface and interfacial tension play a key role in product development. R&D departments around the world are measuring surface and interfacial tension to improve the quality of their products. Detergent formulations are optimized to improve their cleaning properties with lower amounts and more ecological surfactants at lower temperatures. Paints are tailored to stick better on the surfaces they are applied to and drugs are developed to improve their effectiveness. In this short review examples from several industries ranging from laundry detergents to pharmaceuticals are given.

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Surface tension determines the efficiency of detergent formulation

The high surface tension of water makes it a relatively poor cleaning detergent. By increasing the temperature of water (as is often done when washing clothes or dishes), the cleaning efficiency increases slightly as surface tension decreases. The effect of temperature alone is not enough to make water a good detergent and thus addition of surfactants is needed. Surfactants are surface active molecules that adsorb to the interface decreasing the surface tension. Surface tensions are routinely measured when detergent formulations are developed.

Defect-free coatings by surface tension optimization of paints

The basic requirement for paints is that it can form a uniform, defect-free coating on a surface. Many of the surface defects like levelling and orange peel and craters or fish eyes, are related to surface tension and can be solved by fine-tuning it. To affect the surface tension of the paint, small amounts of surfactants need to be added. As lower surface tension can be related to better wetting of the substrate, relatively low surface tensions of paints are needed. However, too low of a surface tension can also cause levelling issues. Due to this, a surface tension balance need to be achieved to have defect free coating.

Interfacial tension is the key factor in enhanced oil recovery

In oil recovery, different enhanced oil recovery methods such as CO_2 flooding are used to increase the recovery rates. After CO_2 is being injected into an oil reservoir, it contacts and interacts with the reservoir oil and brine, thus changing both reservoir equilibrium conditions as well as fluid properties. The effectiveness of enhanced oil recovery is related to issues like CO_2 penetration into the reservoir pores, as well as its ability to displace the brine and oil in the reservoir and lower the viscosity of the oil. Interfacial tension between CO_2 – water and CO_2 - oil is thus important for effective oil recovery.

Interfacial tension determines the stability of food products

Many food products like milk, margarine, mayonnaise and ice-cream are emulsions. An emulsion consists of two immiscible liquids (usually oil and water), with one liquid dispersed in the other as small droplets. In addition to these two phases, emulsions contain emulsifiers that have a key role in the stability of the emulsion. Although it is possible to produce oil-water emulsions by homogenizing them together, the formed emulsion is not stable and will quickly separate into two phases. Emulsifiers are surface active molecules that absorb at oil-

water interface producing a membrane like layer that can prevent the coalescence of the drops and thus stabilize the emulsions. In food products, there are typically some naturally occurring emulsifiers such as proteins and lipids but emulsifiers are also added in production stage. To study the emulsifiers in food products, interfacial tension measurements play a key role.

Surface and interfacial tension affects the performance of pharmaceutical compounds

Surface and interfacial tension plays a crucial role in many pharmaceutical processes from tablet coating to drug solubility and stability. Coatings on tablets are typically used to improve the appearance, mask the taste and odor or control the rate of drug release. Polymers are typically used as coating and therefor the surface tension of the polymer solutions effects on the successfulness of the coating. Surface active molecules are routinely added to polymer coating solutions to lower their surface tension. Thus, knowledge of critical micelle concentration of surfactants is highly important also in pharmaceutical industry.

Interfacial properties have also a clear impact on the solubility of the drug. For example, different types of liposomal delivery systems have been studied to improve the effectiveness of existing drug formulations. Liposomes are composed of phospholipids and cholesterol. To find the optimal ratio of phospholipid, cholesterol and drug for maximal drug release and stability, surface tension of liposome should be estimated.

Emulsion stability is also important in drug development as emulsions based drugs are used especially as injections and personal care products. Surfactants and polymers act as emulsion stabilizers by lowering the interfacial tension between disperse and continuous phases.