Legs in a Glass of Wine

"Legs" in a glass of wine or spirits have been noted since millennia. As noted in Proverbs 23:31, "Look not thou upon the wine when it is red, when it giveth his colour in the cup, when it moveth aright." Descriptions since Biblical times have changed. We now may state, "Wow, just look at those legs!" The language has changed, but the chemistry and physics have remained the same.

Wine and spirits are basically mixtures of water and ethanol (ethyl alcohol). As individual compounds, they have two different physical distinctions. Alcohol has a lower boiling point than water and hence, evaporates faster than water. Water has a higher surface tension than ethanol.

The attractive forces between molecules in a liquid are called **surface tension**. These forces hold the liquid together. The same type a force acts between molecules of a liquid and those of a solid surface. This force is called 'interfacial tension'. If the interfacial tension between a wine and a glass is a bit greater than the wine surface tension, then this causes wine (or spirits) to climb the inside walls of a glass. A point is reached at which the weight of the wine clinging to the glass just balances the force trying to lift more. A pure liquid would arrive at a steady state and a specific film height on the glass would be maintained. Wine is not a pure liquid. It's a water alcohol solution. On the wine film, alcohol evaporates faster than the water. Once the inside of the glass is covered with a thin film, the wine film loses some of its ethanol by **evaporation**. With the concentration of water increasing, the film surface tension increases, as does the index of refraction. In the areas where alcohol evaporates, the watery-wine left behind assumes a drop-like form. The drops become heavier and the force of **gravity** becomes controlling and the drops slides down the glass wall to the wine in the bowl. These legs can be seen because the change in the refractive index makes the boundary between the watery legs and the more alcoholic film visible. The channels of falling wine appear as "legs". Since this "surface tension engine" is driven by the ethanol evaporation in the film, the higher the alcohol, then the greater the legs. Glasses of pure water or alcohol show no legs. Different evaporation rates are necessary. Place two glasses of the same wine side by side. Notice the legs in both. Put a lid on one glass. In the lidded glass, evaporation ceases and legs stop forming.

The elder brother of Lord Kelvin, James Thompson, published a paper in 1855 in Philosophical Magazine, titled "On certain curious Motions observable at the Surface of Wine and other Alcoholic Liquors". Thompson, therein, described the effect caused by capillarity, or surface tension. Thompson described them as "tears of a strong wine".

"The phenomenon stems from the dipole-dipole intermolecular forces in aqueous solutions. The combination of the cohesive forces within the liquid and the adhesive forces between the liquid and solid surface can explain, among other things, surface tension and capillary action. In solution, the ethanol and water have cohesive forces weaker than that of the molecules of pure water. The adhesive forces toward glass surfaces are about the same as those of water. These adhesive forces are stronger than these cohesive ones. This causes wine to adhere to and climb the wall of the glass. As the ethanol evaporates, the cohesive force increases until the wine falls in a thin stream. Upon reentering the surface of the wine, the ethanol concentration is restored, the cohesive forces weaken and again the wine climbs the walls of the glass."

Many wine writers have attributed "legs" to the glycerin in wine. There is no glycerin in wine. There is glycerol, an alcohol. It is in minuscule percentages in wine and may add a touch of sweetness. It has a boiling point of 554º F and does not evaporate like ethanol to create this struggle of forces.

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