

## Light Absorption by Various Beer Bottle Glass:

Data to Accompany April 2<sup>nd</sup>, 2008 Basic Brewing Radio Podcast with James Spencer.

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Light can alter the properties of beer through a general process referred to as photochemistry; chemistry as a result of light (“photo”). The photochemistry details associated with “skunking” of beer have been well investigated and the interested reader is referred to Burns, S.B. *et al.* (*Chem. Eur. J.* **2001**, 7(21), pages 4554-4561). To prevent photochemistry in a beer, beer is generally packaged in brown bottles to prevent photochemistry from occurring. In this short report, we will measure the light that is transmitted through different colors of beer bottle packaging and conclude with some general recommendations.

Shown in Figure 1 (black line) is the emission spectrum (or light given off) from a standard 40W tungsten light bulb (TLB). When this light shines on a bottle of beer, certain wavelengths of light pass through the glass and can potentially alter the beer properties via photochemistry. When beer stored in a clear glass bottle is exposed to light from a TLB, the light is not shielded (the emission spectrum is unchanged – data not shown) and as a result, all wavelengths (shown in black) will pass through the bottle and potentially alter the properties of the beer. When beer stored in a brown bottle is exposed to the tungsten light, the majority of light is absorbed (brown line), hence leading to a greater protection of the beer when compared to the clear glass bottle. When beer stored in a green or blue bottle is exposed to tungsten light, some of the light is absorbed (green – green line; blue – blue line), although the protection is not as great as with the brown bottle. Table 1 presented at the end of this document shows the specific absorption values and percentages at selected wavelengths.

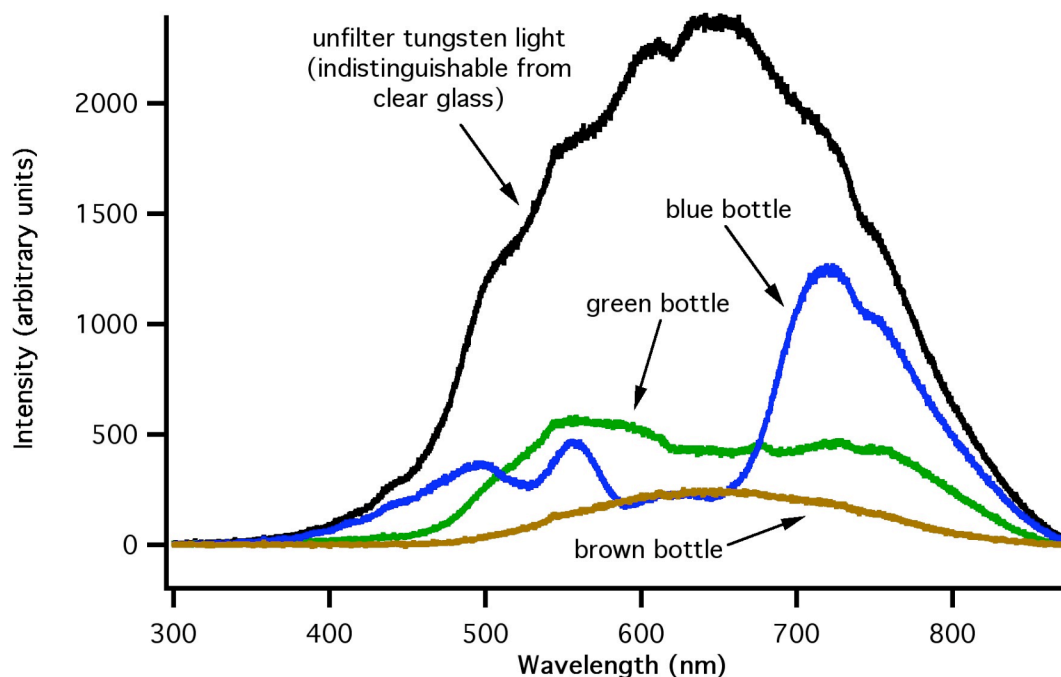


Figure 1: Emission spectra from standard tungsten light bulb (black line), the standard tungsten light bulb filtered with blue glass (blue line), green glass (green line), and brown glass (brown line). Note the visible region is from ~400 to 700 nm, ultraviolet region is ~280 to 380 nm, and the infrared region is greater than ~700 nm.

The question arises, what wavelengths of light affect the beer the most? The answer is, the higher the energy of light, the more the potential for damage. Higher energy light has a shorter wavelength; therefore 400 nm light is higher in energy than 500 nm, and 500 nm light is higher in energy than 600 nm, and so on. This result is not unfamiliar to most. When we go outside on a sunny day, we usually apply sunscreen to block the high energy light. This high energy light is usually associated with ultraviolet (UV) light that has a wavelength of 280 to 380 nm. From the data presented in Figure 1, a tungsten light bulb does not emit any UV light. This is a good thing or else we would have to apply “sunscreen” even when we were inside. The data presented in Figure 2 is when the sun is the source of light. Note that the emission spectrum from the sun is quite different from that of the tungsten light bulb. The sun’s spectrum is shifted to higher energy wavelengths. As with the tungsten light bulb, clear glass does not protect the beer in any way from photochemistry (data not shown). The same trends in filtering (or absorption) due to the different color of beer bottle glass still exists; brown glass filters the largest amount of high energy light. Note that the green and especially blue are inefficient at filtering the higher energy UV light (less than ~ 400 nm). Table 2 presented at the end of this document shows the specific absorption values and percentages at selected wavelengths.

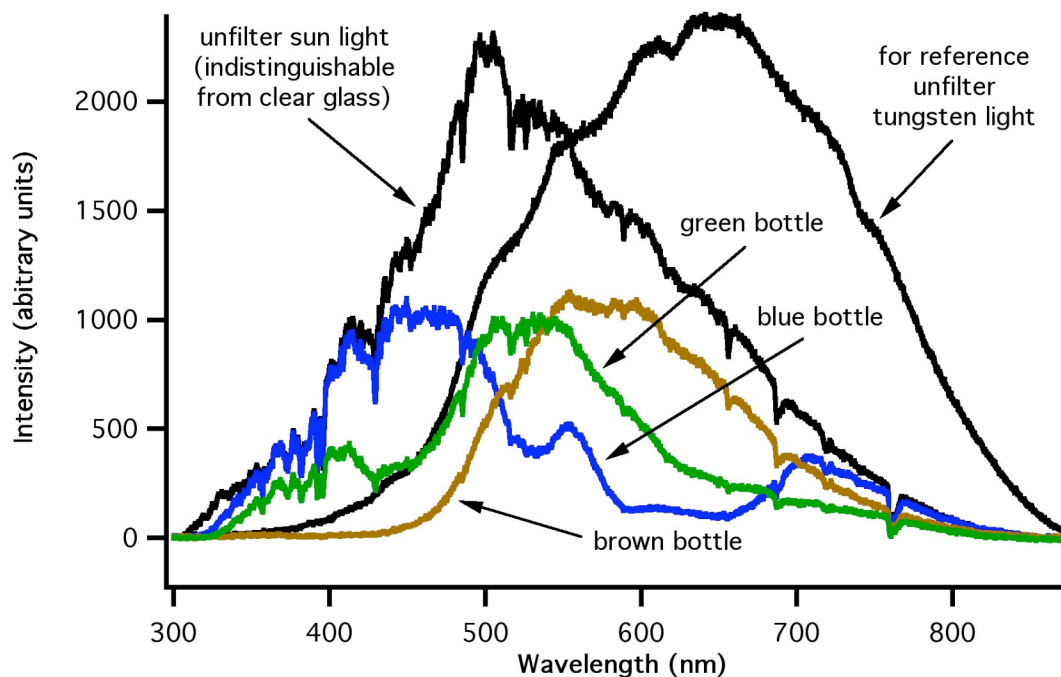


Figure 2: Emission spectra from the sun (black line – left), standard tungsten light bulb (black line - right), the sun filtered with blue glass (blue line), green glass (green line), and brown glass (brown line). Note the sun produces significantly more ultraviolet light when compared to the tungsten bulb.

So it is clear that drinking beer outside on a sunny day may promote photochemistry leading the “skunking,” but what about a standard fluorescent light bulb (FLB) we find in the store beer refrigerator? The data presented in Figure 3 is when a standard fluorescent light bulb (FLB) is the source of light. Note that the emission spectrum from this FLB is quite different from that of the sun or the tungsten light bulb. The FLB spectrum has well defined emission lines due to the fact that the FLB works based on the excitation of mercury vapor. The well defined emission lines of de-exciting mercury hits the phosphor on the inside surface of the bulb and reemits the energy in a broader range than the mercury vapor alone. Of particular importance is the high intensity, high energy 434 nm emission line. As with the sun and tungsten light bulb, clear glass does not protect the beer from photochemistry (data not shown). The same trends in filtering due to the different color of beer bottle glass still exists; brown glass filters the largest amount of high energy light. Table 3 presented at the end of this document shows the specific absorption values and percentages at selected wavelengths.

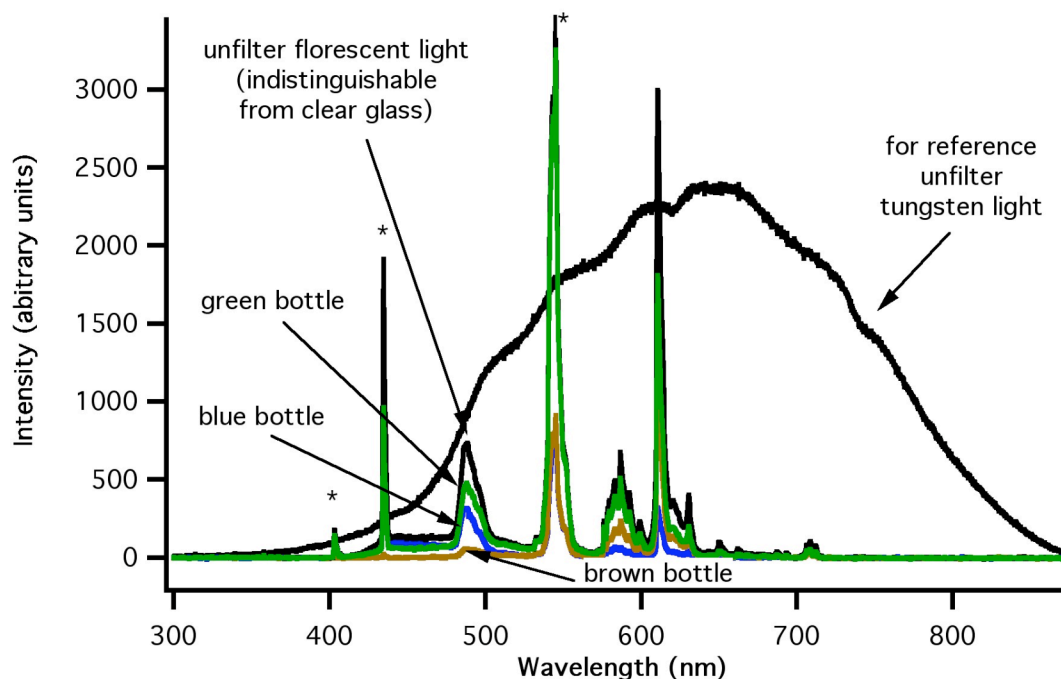


Figure 3: Emission spectra from a standard fluorescent tube (black line – sharp), standard tungsten light bulb (black line - broad), fluorescent light filtered with blue glass (blue line), green glass (green line), and brown glass (brown line). Emission lines from mercury are labeled with an asterisk.

## RECOMMENDATIONS

Continue to use brown bottles for all homebrew!

**Additional data:**

Table 1: Measured absorbance (Abs) by colored glass beer bottles at various wavelengths. Light source is a 40 W tungsten light bulb. Data measured from Figure 1.

<b>Filter</b>	<b>Intensity 400 nm</b>	<b>% Abs 400 nm</b>	<b>Intensity 450 nm</b>	<b>% Abs 450 nm</b>	<b>Intensity 500 nm</b>	<b>% Abs 500 nm</b>
<b>No filter</b>	88	Na	310	Na	1177	na
<b>Blue</b>	65	26%	197	36%	367	69%
<b>Green</b>	21	76%	44	86%	272	77%
<b>Brown</b>	0	100%	0	100%	41	96%

Values are estimated at  $\pm 3\%$ .

Table 2: Measured absorbance (Abs) by colored glass beer bottles at various wavelengths. Light source is the sun. Data measured from Figure 2.

<b>Filter</b>	<b>Intensity 325 nm</b>	<b>% Abs 325 nm</b>	<b>Intensity 350 nm</b>	<b>% Abs 350 nm</b>	<b>Intensity 400 nm</b>	<b>% Abs 400 nm</b>
<b>No filter</b>	159	Na	284	na	785	Na
<b>Blue</b>	42	74%	256	10%	744	5%
<b>Green</b>	14	91%	148	48%	402	49%
<b>Brown</b>	5	97%	11	96%	19	98%

Values are estimated at  $\pm 3\%$ .

Table 3: Measured absorbance (Abs) by colored glass beer bottles at various wavelengths. Light source is from a standard fluorescent light bulb. Data measured from Figure 3.

<b>Filter</b>	<b>Intensity 403 nm</b>	<b>% Abs 403 nm</b>	<b>Intensity 434 nm</b>	<b>% Abs 434 nm</b>	<b>Intensity 488 nm</b>	<b>% Abs 488 nm</b>
<b>No filter</b>	176	Na	1911	na	733	Na
<b>Blue</b>	145	17%	1494	22%	314	57%
<b>Green</b>	143	19%	960	50%	476	35%
<b>Brown</b>	0	100%	23	99%	50	93%

Values are estimated at  $\pm 3\%$ .