Polarizers in Brief

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This is a 2 page version of the larger, 5 page document on Polarizers. It assumes you know how to use them. The full version has more about the physics of light and images showing the effect of polarizers. Get both if you wish … they are free!

You have probably heard that these filters polarize and un-polarize the light. This is not true. A single light wave has a specific direction of vibration. But in nature, all subjects are illuminated by a 'bazillion' light waves, vibrating in random directions. This illumination is said to be unpolarized, but 'random' or 'incoherent' would be more correct.

Polarizers Work by Subtraction

Light that has passed through a polarizer is composed of rays that vibrate in about the same direction. When you turn a polarizer, you are choosing the 'polarization angle' of the light that passes through the filter. This is called polarized light. The polarizer does not create polarization; it simply removes the light rays not vibrating in the chosen direction. Because they subtract light, polarizers always require a corresponding adjustment to your camera's exposure settings. All photographic filters work by subtraction, removing some component of light.

If you stack two linear polarizers, you can change the amount of the light passing through them by rotating one of the filters. The maximum effect is obtained when the polarization angles are at right angles (90°). This is how variable neutral density filters work. the In an optics lab, the first filter is called the *polarizer* because it provides a stream of light vibrating in one known direction. The second filter is called the *analyzer*. Rotating the analyzer will lighten or darken the light if it has some degree of polarization.

Practical Magic

Normal human vision cannot detect polarization. This is the magic of polarizers; they enable us to detect if light in nature has some degree of polarization, and to control how that light is blocked or allowed to pass through. In photography, we use the polarizer filter as an analyzer!

The polarizer filter is actually a *'Polarization Angle Analyzer'*.

The two sources of polarization in nature are scattering and reflection.

Scattering

Light is an electromagnetic wave. The negatively charged electrons in the atmosphere's nitrogen and oxygen atoms respond to these waves. They scatter blue wavelengths strongly at right angles (90°) to the inbound rays. This is why the sky away from the sun is blue and why the greatest sky-darkening effect of the polarizing filter follows the 90° rule for sky darkening

'Golden Hour' light has passed through more atmosphere, more blue wavelengths have been scattered away. 'Blue Hour' light comes from the sky overhead scattering blue light when the sun is just below the horizon. Blue hour skies can be darkened with a polarizer because of scattering.

Polarizers can also reduce haze in distant subjects, which is scattering by particulates.

Reflection

Light reflected by most materials is polarized to some degree. There is one angle at which 100% of the reflected light is horizontally polarized. All of the light reflected at that angle can be blocked by your polarizer. (Your *polarization angle analyzer,* of course!) This angle is known as Brewster's Angle, as explained by the Scottish physicist Sir David Brewster in 1815. Brewster's Angle differs slightly for different materials, but all are close to 55°. However, the effect is strong between 40° and 60°. Note that there is no 90° rule for reflections!

Linear and Circular Polarizers

The first layer of all polarizing filters is a linear[*] polarizer. This includes both the simple polarizer and the circular polarizer (CP or CPOL). The circular polarizer passes light through a second filter[†] which causes the direction of the light's electric component to rotate. Both types produce identical visual effects. Why we need circular polarizers for modern cameras, particularly DSLRs, is part of the longer paper.

Photographers often evaluate the effect of a polarizing filter by eye before mounting it to the lens. The CP filter effect should be viewed *from the camera side*. This is very important for reflections, which have a dominant plane of polarization. Sky effects can be seen from either side, but camera side works best. To see the stacked polarizer effect using two CPOL filters, just hold them face-to-face; the light then pass between the two linear polarizers sequentially.

Conclusion

- ✓ The polarizer on your lens does not polarize or un-polarize the light; it only passes or blocks naturally polarized light.
- ✓ Both reflected and scattered light can be selectively blocked by turning your polarizer.
- ✓ Polarization in nature is caused by scattering (the sky) or reflection (water, wet surfaces, leaves).
- ✓ Scattering in the sky is strongest at 90° from the sun.
- ✓ Reflected light can be totally blocked at Brewster's Angle but the effect is strong between 40° and 60°.

The full version of this document has more details about the physics of light and example images. There are also some special 'Gotcha' situations you should know about!

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[*] The modern linear polarizing filter was invented by Edwin Land. Polyvinyl alcohol polymers doped with iodine are embedded in a thin film that is stretched to align the molecules. He formed the Polaroid Corporation to manufacture these filters. He later invented the Polaroid Camera, also known as the Polaroid Land Camera.

[†] This filter is a thin film 'quarter-wave plate'. See this Wikipedia article about wave plates.