Clay’s guide to buying a light

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General information

What are you looking for in a light?

The first question you should consider when looking to buy a light is “what will it be used for?” Once you know what you're using it for, you can move on to some more specific questions: should your light light up a large area (flood) or put a spot on a wall 70ft away (spot); does it need to be perfectly waterproof(IPX8), or will it be in a dry area; are you using it for PC repairs? Then it doesn’t need to be waterproof; are you going caving with it? Then it needs to be impact-resistant and waterproof.

Useful Terminology

- Flood: a flood light will fill up a large area, but will not light things that are far away from you.
- Throw: these lights will light up far away from you in a focused beam, but will not light up large areas.
- Hot Spot: the central brightest spot of the light.
- Spill: the light around the Hot Spot.
- Lumens: the total amount of light produced by the emitter.
- Lux: the intensity of light at one spot.
- Boost: a type of driver that increases the voltage fed to the Emitter/emitters. Drop-in: easily modifiable or replaceable parts.
- CRI: Color Rendering Index, how well you can differentiate color with it (UV lights are very low).
- Tint: the color of the light as compared to white. (can be green-ish/red-ish).
- Temperature: the color of ‘white’ you get. 5600-5700K is considered true sunlight (lower numbers are warm/yellow, higher numbers are cold/blue).
- Driver: the circuit that controls how much power is fed to the emitters.
- Emitter: a collection of LEDs at a set temperature (K).

- mAh: unit of battery capacity (abbreviated from milliamp/hour). Can be used to calculate drain/runtime.
- IPX: the waterproof rating. This is regulated, so if it claims an IPX (Ingress Protection), it is likely to be true.
- Cell: battery.
- Li-ion: lithium-ion
- LiPo: lithium-polymer
- EDC: Every Day Carry

Battery/cell safety

Cell types, protected and unprotected, general safety

There are many types of cells. The most commonly encountered day-to-day batteries are alkaline batteries (AA, AAA, D, and C cells that you can buy at Walmart/Lowe's are almost all alkaline). Lithium-ion or lithium-polymer batteries (18650, 21700, and 14500 cells are often found in tool batteries and power banks.

Alkaline cells are rechargeable only a few times (2-3), but it can be dangerous to do so, as they can easily catch fire (high internal resistance and damage from draining). Alkaline cells are generally single-use cells. On the other hand, lithium-ion and lithium-polymer cells can be recharged thousands of times before noticeable loss of performance.

Almost all types of cells have protected or unprotected versions. Protected cells or button-top cells have PCBs to prevent short circuits, over-discharge, and overcharge. This means that these cells are much harder to set on fire. Conversely, unprotected cells or flat-top cells don't have this protection and rely on the flashlight or charger's driver for this.

Following this, if a cell has a damaged wrapping, it can contact the inside wall of a light, causing a short circuit. This can lead to thermal runaway and fire, so it’s best not to use it. Do not carry loose cells around. If you do, and they contact metal, they may short and set your pants on fire. (This has happened)

Li-ion batteries and water do NOT mix at all. Alkaline cells can corrode and ruin your light; lithium-ion/polymer cells can catch fire or explode. This is why waterproofing is so important.

Common types of cells

- 21700: These cells are 21mm across and 70mm tall. They are very commonly used in EDC lights along with 18650s
- 18650: These cells are 18mm across and 65mm tall. They are very commonly used in EDC lights along with 21700s
- 18350: These cells are 18mm across and 35mm tall; these are generally used in compact lights
- 14500: These are 14mm across and 50mm tall. These cells are the same size as an AA but are not always compatible with lights made for AA cells, as they have a higher voltage output.
- AA, AAA: common, generally single-use cells.

Waterproofing (IPX) Rating

Waterproofing is important for any electronic, especially those with Li-ion cells. Because of this, there is a rating that is regulated and can generally be trusted: this is marked on lights as an IP## or IPX#.

The IPX rating is read this way: IP0-6X is for dust protection, and IPX0-8 is for water, so an IP41 rating means that the device will keep out most wires and large ants and will be protected from dripping water as long as the drop is vertical.

IPX ratings:

1. IPX0 = no protection
2. IPX1 = protected from condensation/droplets
3. IPX2 = protected from rain/spraying water 15° from vertical
4. IPX3 = protected from spraying water 60° from vertical
5. IPX4 = protected from splashing from any angle
6. IPX5 = protected from low-pressure jets of water from any angle
7. IPX6 = protected from high-pressure jets of water from any angle
8. IPX7 = can be submerged for 30 minutes at less than 1 meter
9. IPX8 = can be submerged more than 1 meter continuously

Emitters, CRI, Tint, and Temperature

Emitters

There are a lot of different emitters—too many to cover in this guide. Many emitters come in several different temperatures, for example, the B35AM comes in: 6500K, 5700K, 5000K, 4500K, 4000K, 3500K, 3000K, or 2700K. Different emitters have different properties, so if you want something specific, it would be a good idea to find a spec sheet for the emitters you are considering. Some of the common emitters you will see are:

- Nichia 519A, CRI = 95-97
- SFT-40, CRI varies with CCT
- SFT-25r, CRI =~70
- SBT-90.2, CRI =~70
- XHP-70.3 HI, CRI =~70-80
- B35AM, CRI = 90-95

Tint (Duv)

The tint of a light is determined by how close it is to what is considered ‘white’ for a given temperature. This perfect color at a specific temp falls along the Black Body Locus. A negative

Duv means that your light will have a warm/rosy tint, which some people enjoy and can look nice, but will not give you accurate color if that's what you are after, and a positive Duv means a colder/green tint that most folk tend to dislike.

Temperature (CCT)

Temperature is a measure of how warm/cold a light will be; lower numbers are warmer, higher numbers are colder. Daylight is considered to be around 5200-5700K; this can change depending on your latitude.

Warmer lights are nice if you want a warm light; they are good for floods, but are not great for throwers. The colder lights are better for throwers but can seem harsh up close.

These temperature measurements are taken in Kelvin and are based on the color emitted by a tungsten filament at different temperatures; this is why there is a ‘K’ at the end of the numbers.

Color Rendering Index (CRI)

The Color Rendering Index is based on how close a light is to sunlight (~100). This means that a light with a lower CRI will not differentiate colors as well as one with a higher CRI. If you are doing something where the ability to differentiate color and depth is important (electrical work, running at night, or scientific photography), you want a higher CRI.

Laser Excited Phosphor (LEP)

A type of light you may see, these are not super common and tend to be fairly expensive, but they are the best throwers you'll find.

Scams to look out for and brand recommendations (Mostly based on personal experience)

Scams

The most common ‘scam’ you will see is lights with insane lumen counts; they will claim to have over a million lumens in a headlamp. To my knowledge, the brightest light that is technically man-portable is 120,000 lumens made by Will Hart, and it is about 2ft long and weighs over 40 lbs because it has 6 copper heat sinks and is water-cooled. So keep that in mind when buying lights.

The second common scam I have run into is with cells. When buying cells, you will sometimes see a cell (18650/21700) advertised with 99,999 mAh. This is a lie: the highest capacity 18650 is around 4000mAh, and the highest capacity 21700 is around 6000mAh. So keep this in mind when you are buying extra cells for your lights.

It is important to mention that as batteries improve, the capacity will increase.

Some reliable brands

There are a lot of different brands of lights, and even more knock-offs. If you're unsure if a brand is reliable, look it up, and someone will likely have an answer. Along the same vein, if you want more information on a specific light, someone has probably written a review of it or made a video. I recommend looking at Reddit and YouTube for reviews.

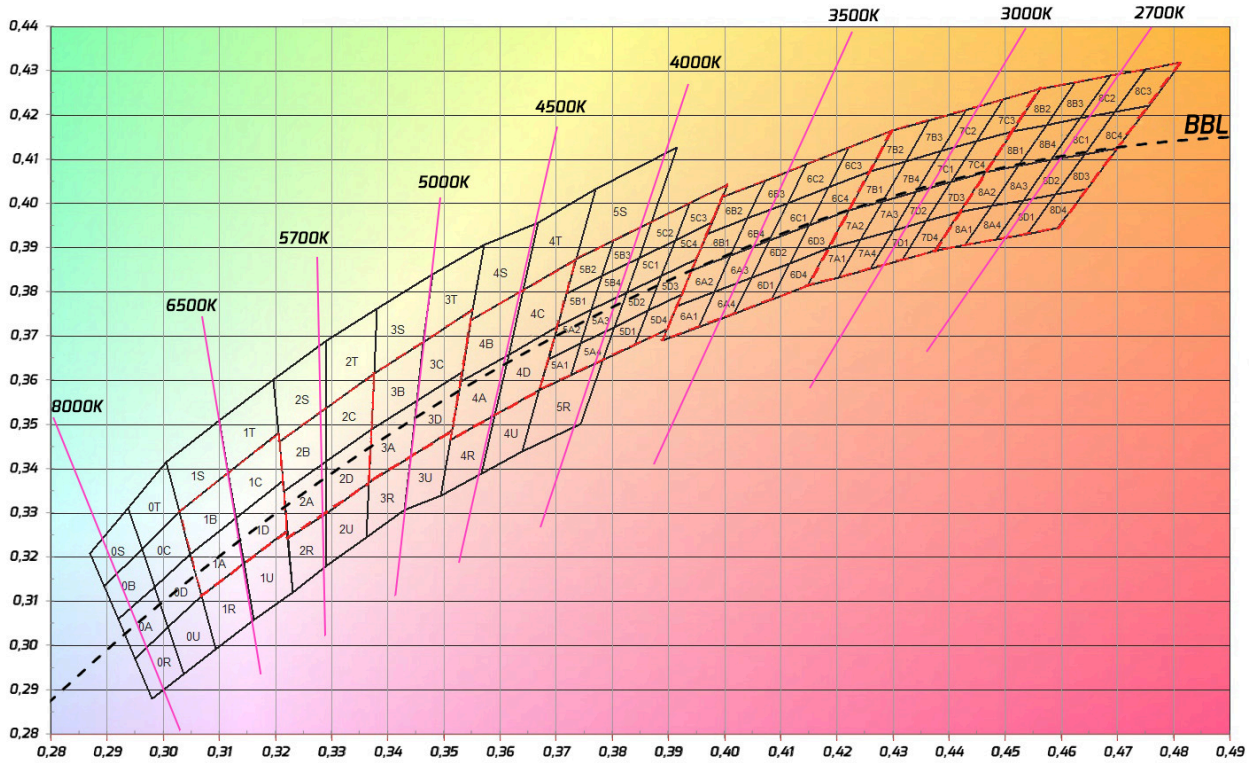
Here are some brands I have experience with:

- Convoy Light: They are cheap, fairly durable, and incredibly modifiable, configurable, and repairable. A nice light from them costs $10-$30, and their individual replacement parts range from a few cents to $2-3. Not only are they cheap and repairable, but they work consistently. I like these lights mainly because you can fix them (Right to repair is a wonderful thing)
- Zebralight: though expensive, you get what you pay for. I accidentally took one of their headlamps scuba diving in the ocean and took it over 70ft down without incurring damage. I also dropped the same light from a second-story window; there was no damage, it still works to this day, and it's over 8 years old. They also have a $25 out-of-warranty repair (it does take about 2 months).
- Wurkkos: they are a jack of all trades, and not terribly expensive (they have sales all the time), and they have lights for everything—laser, flood, spot, and UV, and some that are just a spot. They are durable but are difficult to fix, sometimes impossible. However, they have good customer service and will fix or replace your light as long as the fault is not obviously yours.
- UVbeast: they are one of the best for UV lights, along with Convoy (cheaper, fewer options).
- Coast: they work consistently and tend to have cooler emitters. They are tough and have better heat management than Wurkkos. but are generally overpriced and are not repairable.
- Other lights I have heard good things about, but do not have any experience with:
    - Sofirn
    - Skilhunt
    - Acebeam
    - Firefly

There are, of course, many more reliable brands, but these are a good starting point and should cover just about any need.

Graphs and pictures

LED Tint Graph



https://toykeeper.net/torches/cree-tints.jpg

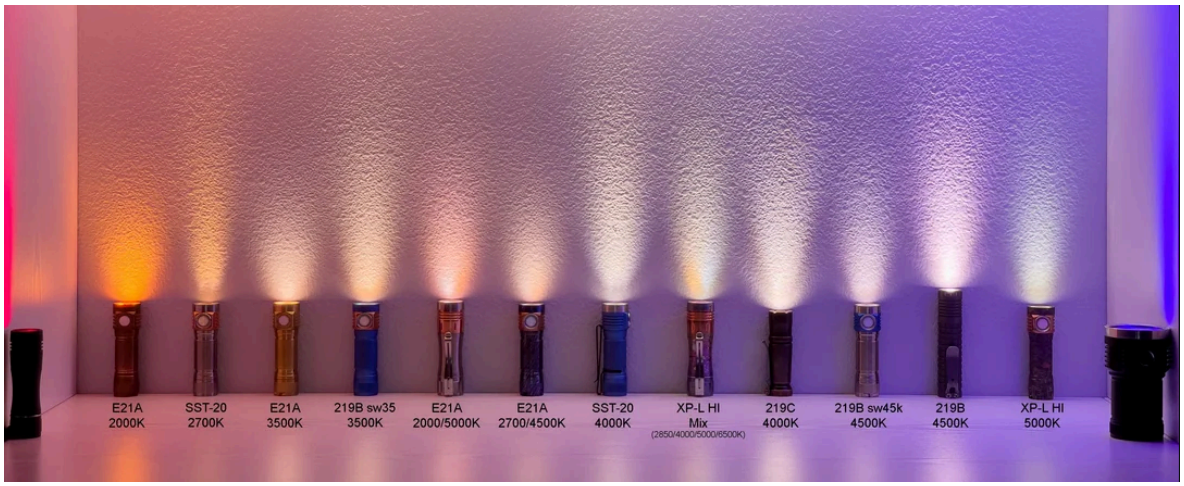
Tint and Temperature

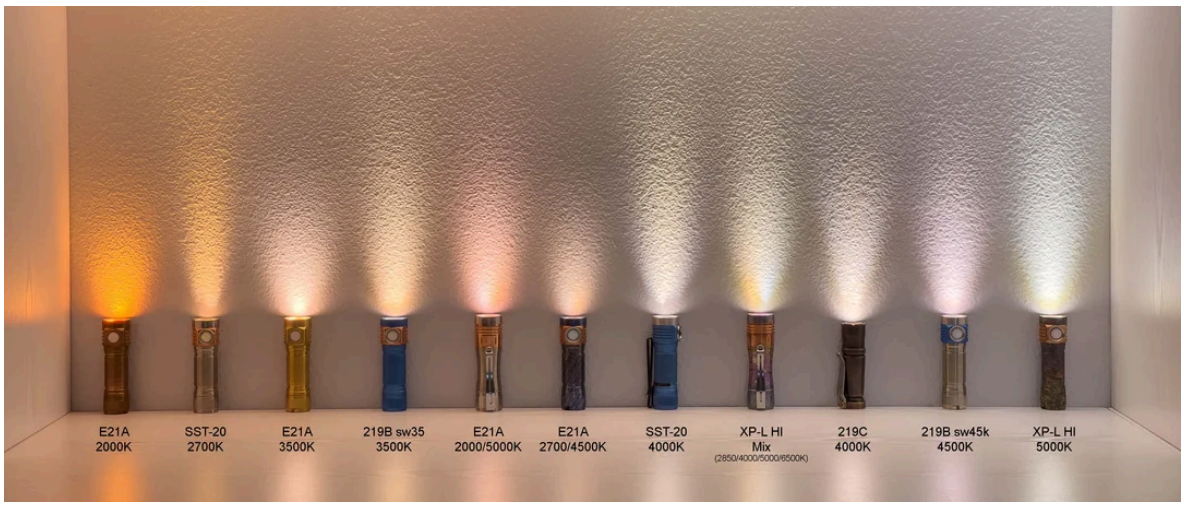






The three photos above are from [this post](#).^

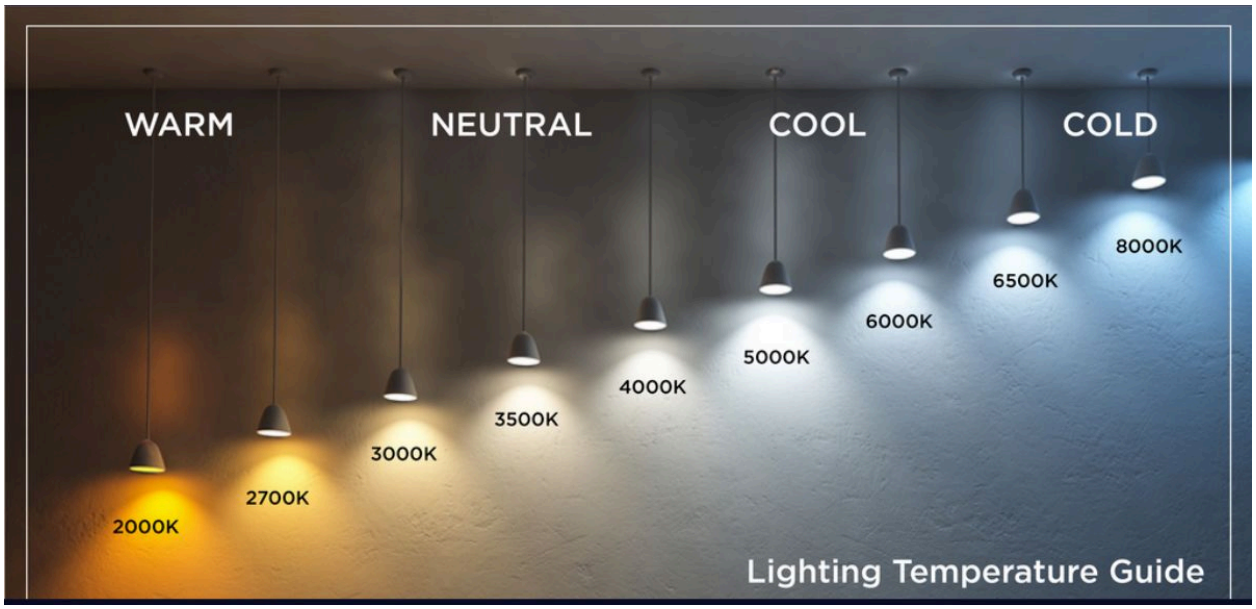




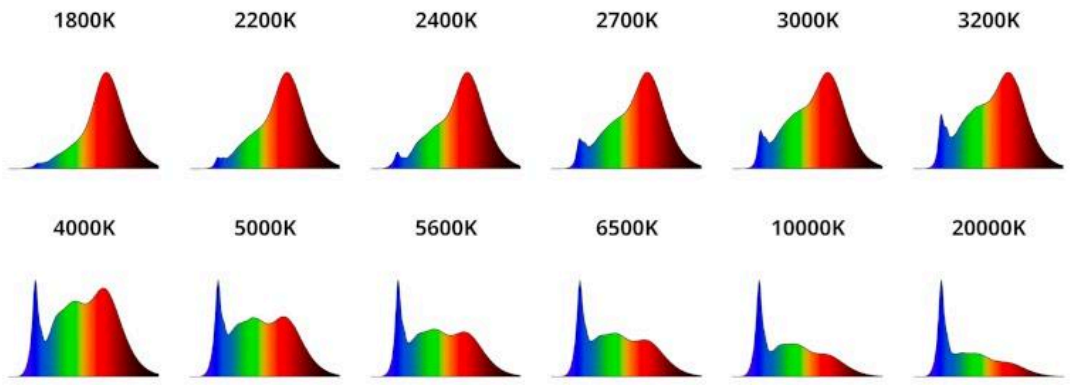
The two photos above are from this [post](#).^



[Original post](#).^



Relation of Tint, Temp, and CRI



CRI



From the comments on this post. There are other photos here and a useful discussion.^



Original post.^

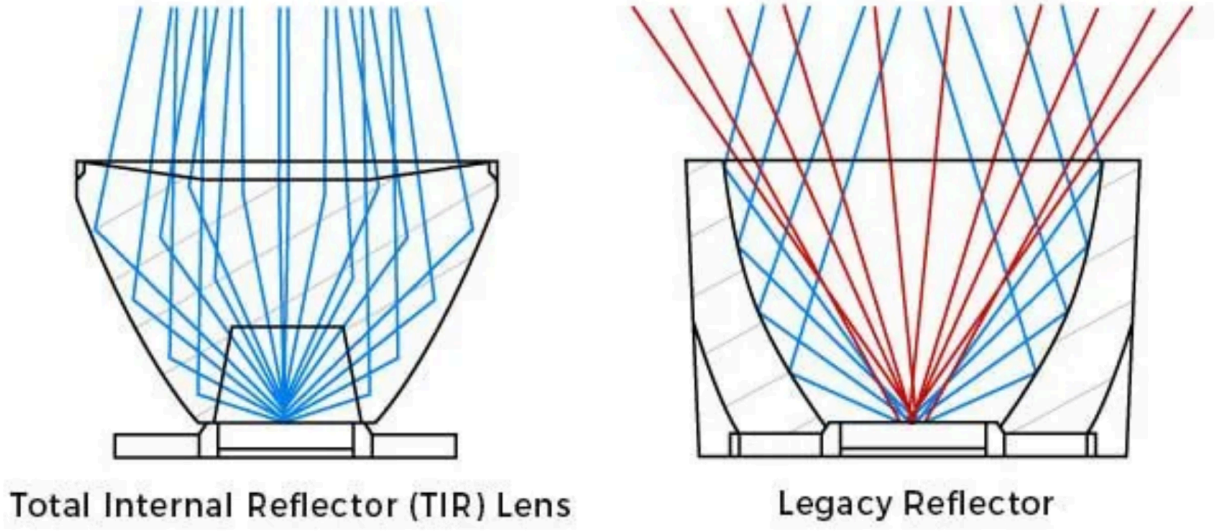
Flood vs. Throw, TIR vs. Reflectors, Smooth vs Orange Peel reflectors

Flood vs. Throw



[Original post](). ^

TIR vs. reflector



From the comments on this post.^

Smooth vs. Orange Peel reflector



Original post. (smooth on left, orange peel on right)^

Compared to a smooth reflector, an OP reflector gives a smoother transition between hotspot and spill, at the expense of some throw. If the LED has artifacts (such as a quad-die construction), an OP reflector is often preferred to smooth out a dark hole in the center of the beam.

The loss of throw depends on the size of the LED; the smaller the LED, the more throw is lost, going from smooth to OP. Contrary to popular belief, an OP reflector does not generate more flood/spill, because spill comes from light emitted directly from the LED without ever hitting the reflector.

Clays recommendations

Hand Lights

- My top recommended hand light for a spotlight/good throw is the Convoy S21E with a 10° flat TIR lens. I like the 6000mAh 21700 cells for these, as they will run for roughly 3h at that capacity. (~$30)
- My second recommendation is the Convoy S2+, as it has the most options, you can get TIR lenses for it, and you can swap the switch on the back between a few different options. (With Vapcell N41, it is ~$23)
- I really like the HD02 (the Pro version too). The reason it's not my top recommendation is that it is expensive on sale, it hovers around $80 when it's not on sale its $120. The reason I strongly recommend this is that it can do everything; it's very bright and has a decent throw with its spotlight. The wing lights are great for photography, the laser is very bright (less so on the Pro). The UV light is 365 and bright as UV lights go, and the magnetic tail cap is amazing for hanging it on stuff. The Pro version also has red light so you don't disturb animals and can keep your night vision intact.
- Last is the TD04. I don't particularly like this light, but that's because it floods a wide area, and that's not what I'm after in a hand light. It works well and will light up a large area close to you, it has a decent run time too.

Headligths

- My top recommendation for headlights is Zebralights 18650 headlights, they are incredibly efficient and very, very durable. I use the 2 I have as my caving lights and have smashed them into more than a few rocks. The older light (7 years) I once took over 80 feet down into the ocean for 2 hours. They are a bit pricey at $99, but it's worth it.
- My only other recommendation is the Convoy H series, they are fairly durable though not nearly as waterproof as the Zebras, they are much easier to fix yourself and still decently efficient. They are also much cheaper than the zebralights at around $30.

UV Lights

Considerations

There are several options that are important to consider when looking for a UV light. Are you looking for bodily fluids? Bones? Specific mineral? Different wavelengths will affect materials differently.

You also have to think about how much visible light you are producing, as this can wash out any fluorescents caused by the UV light. This can be mitigated by a ZWB filter. You can't filter 395nm UV or 400nm UV, as those wavelengths are mostly visible light and, as such, would be entirely blocked by a ZWB filter. ZWBs reduce the amount of blue light produced and thus cut down on headaches caused by prolonged use of UV lights.

Another consideration is the power draw. Shorter wavelengths generally require more power, so a 1000mAh cell will be drained faster with a 255nm LED than with a 365nm LED.

Use cases:

Bones

Bones will fluoresce best under filtered 365nm UV. You can get several lights in the wavelength that are fairly powerful and have a decent throw.

Fluids

For most bodily fluids (Like cat pee), you will want an unfiltered 395nm UV light, as shorter wavelengths will not make the fluids glow nearly as bright.

Minerals

If you are using UV on minerals for general display, a filtered 356nm will make the most variety glow. If you are trying to ID contaminants or the mineral itself based on its fluorescence, you will want at least 3 different wavelengths: 365nm, 310nm, 255nm all filtered with ZWB1-2-3 filters.

Brands

Convoy (Link)

This is a good brand as they are easy to fix, and parts can be replaced and are cheap. The S21A (UV) has a lot of power behind it and can throw at least 70 feet in low light. More in near total darkness.

These lights are fairly inexpensive, and there are a few options: the T3 (365nm, filtered, 14500 cell, $16.50) is small but has little distance and a short battery life, the S21A (365nm, filtered, 21700 cell, $30) has a lot of power and distance with a decent battery life, the C8 has an ok batterie life and throw depending on wavelength (310-255nm, filtered, $45)

One downside to this brand is that all of the UV lights lack a USB-C port, and so all cells must be charged externally.

Engenious Designs (Link)

This company offers 310nm in a smaller casing than Convy.

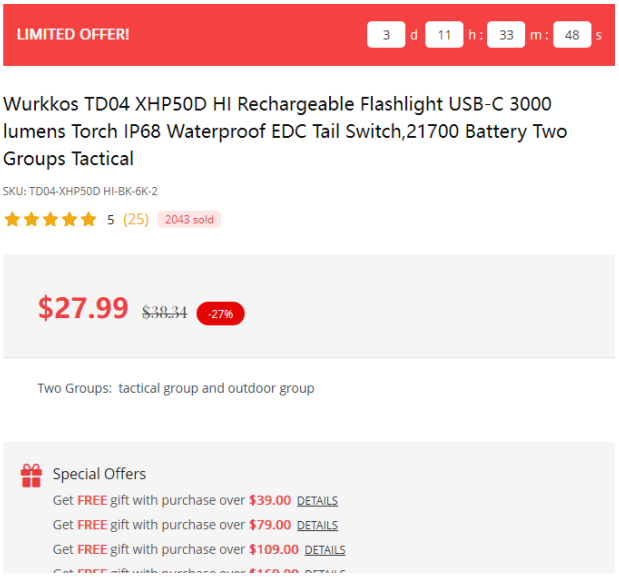
Stimac Engineering (Link)

This brand is expensive, with the cheapest light being $75. However, they have the most options when it comes to wavelength.

Pictures of lights to showcase the company's general style

Wurkkos



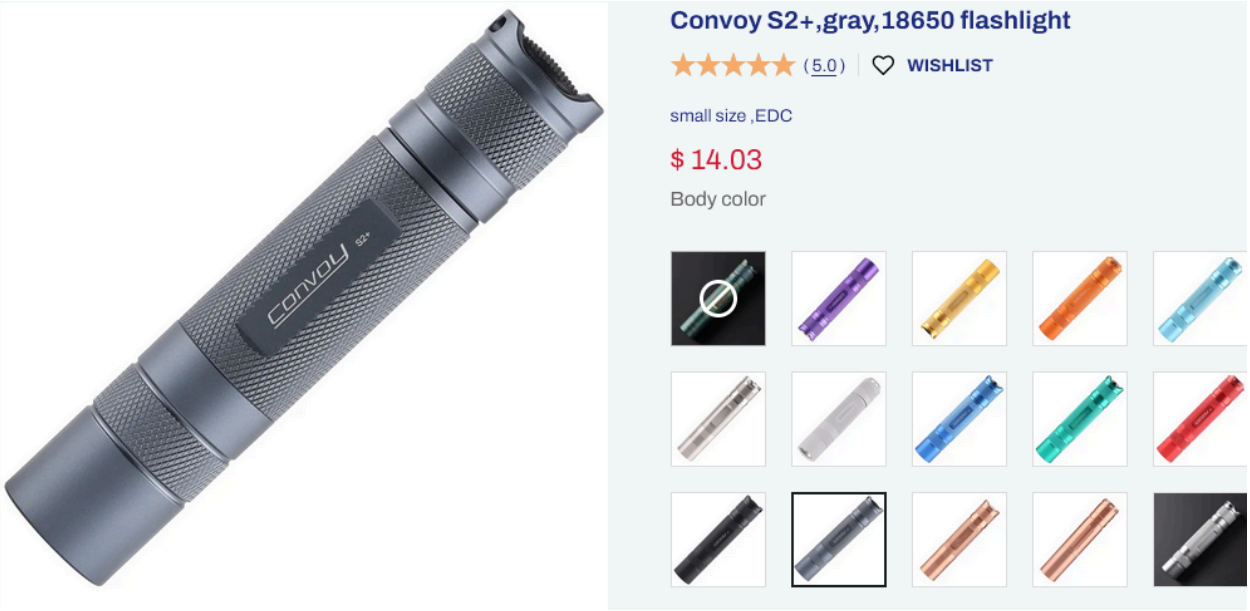


Zebralight





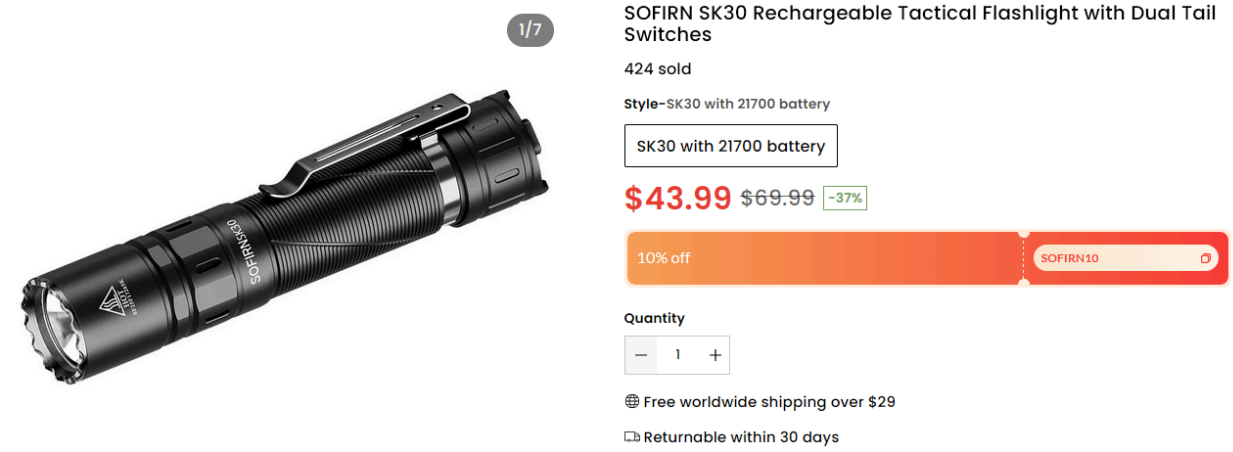
Convoy Light



Coast



Sofirn



Firefly



L50 Sol - EDC Right-Angle Flashlight

$59.00

★★★★★ 4.97 | 31 reviews

Body Color: Navy Blue

Emitter Type: FFL5009R 5000K CRI95 2200lm 220m

FFL5009R 5000K CRI95 2200lm 220m

FFL5009R 4000K CRI95 1900lm 190m

FFL5009R 3500K CRI95 1900lm 190m (Rosy)

Acebeam



★★★★★ 4.9 | 18 review(s) | Add your review

E75 High-performance Quad-core EDC Flashlight

$99.90

The ACEBEAM E75 is a high-performance quad-core EDC flashlight that delivers up to 4500 lumens of floodlight beam, powered by one included 5000mAh 21700 Li-ion battery. There are 5 colors and 2 color temperatures available for your choice. The high CRI Nichia 519A LEDs render soft, non-glaring light. It supports USB-C direct charging. Its metal side switch can indicate the remaining power levels for real-time monitoring, and the magnetic tail cap allows for hands-free usage. With a traffic wand, it can be transformed into a traffic light or reading light. Built tough from premium ALG061-T6 aluminum alloy with HAIII hard-anodized finish, it is sturdy and durable. Suitable for hiking, patrolling, power outages, and more.

Free shipping

* Color & LED Options

- Black - 4*TN Cool White 6500K
- Ceramic Pink - 4*TN Cool White 6500K - Limited Edition [+$29.90]
- Ceramic Blue - 4*TN Cool White 6500K - Limited Edition [+$29.90]
- Ceramic Blue-Pink- 4*TN Cool White 6500K - Limited Edition [+$29.90]
- Ceramic Purple-Green - 4*TN Cool White 6500K - Limited Edition [+$29.90]
- Ceramic Pink-Blue - 4*TN Cool White 6500K - Limited Edition [+$29.90]
- Rainbow Titanium Porcelain - 5000K High CRI90 LEDs - Limited Edition [+$49.90]
- Rainbow Titanium Porcelain - TN 6500K LEDs - Limited Edition [+$49.90]
- Rainbow Titanium Tiger Stripe - 5000K High CRI90 LEDs - Limited Edition [+$49.90]
- Titanium Horse - 4*TN Cool White 6500K - Limited Edition [+$49.90]
- Rainbow Titanium Tiger Stripe - TN 6500K LEDs - Limited Edition [+$49.90]

Other good resources to learn about lights

In absolutely no organized manner, here are a bunch of links to resources talking about flashlights and cells:

- Guide to TIR lenses
- Wikilight
- Selfbuilt's Flashlight Reviews
- Fonarik Flashlight Reviews
- Going Gear
- 1Lumen.com Flashlight Reviews
- Flashlight Wiki's terminology page

- Grizzly's Convoy guide
- r/flashlight's guide
- Anduril 2 programming guide
- Zebralight programming guide
- Zebralight spreadsheet
- Veritasium: lithium cells
- Veritasium: blue LEDs
- Random Reddit posts one and two
- In the google drive folder "the only folder reddit gets access to" there is also a safety guide with links to videos, websites, and an OSHA factsheet.

Special Thanks

Special thanks to all of the wonderful people on the r/flashlights subreddit who read through this and offered suggestions on content and caught a ton of my spelling and grammar mistakes.

Especially u/HoardOfPackrats, who read and edited the entire paper without this, this would be no were neat as legible as it is now, u/QReciprocity42 for the clarification on smooth vs OP reflectors, and u/-nom-de-guerre- for correcting me on lux/lumin info as well as giving me the idea for the overall format.