

## + What is indigo?

Indigo is a rich, deep blue colored dye used most often to dye denim. Indigo dye was originally derived from natural sources, specifically the leaves of the *Indigofera tinctoria* plant. Today, due to high demand, the vast majority of indigo dye is synthetically produced from oil. Several thousand tons of synthetic indigo are produced each year worldwide.

Indigo is a vat dye that is insoluble in water. It has poor wash fastness and lightfastness, and it fades easily in the presence of chlorine bleach. However, it is precisely these qualities that make indigo such a valuable dye for the denim industry. Jeans are commercially washed in garment processing facilities. They go through a series of processing steps that may include stone washing, bleaching, softening and sandblasting to produce the abundance of visual aesthetics so commonly associated with denim.

## + What is the application of indigo dye?

Indigo is used to dye denim which is made from cotton. The vast majority of indigo used in the denim industry is synthetic and made from petroleum. The indigo is almost always applied to yarns rather than fabrics. Because it does not dissolve in water, a strong reducing agent such as sodium hydrosulfide is required to make the indigo dye water-soluble. This reaction requires alkali to raise the pH.

Once the dye is water-soluble, it can be absorbed easily by the yarn. After the yarn is removed from the dye solution, it is left in the air to oxidise and become water-insoluble again. The depth of shade occurs by dipping the yarn in consecutive baths of indigo solution, thus building the color up in layers. This is important because many processes in the garment washing stage are used to “chip off” the color, thus showing the white core of the yarn, which gives denim its characteristic stonewashed appearance.

After the fabric is made into jeans, further processing is required to give denim jeans their faded or stonewashed aesthetic. These wash steps, done in the garment form, use chemicals which create effluent that needs to be treated prior to discharge. This effluent is the main problem with denim processing.

## + What currently limits indigo dye as an input for the circular economy?

There are issues with indigo dye as an input for the circular economy at each stage of the use-cycle of the dye. While indigo can be sourced from a rapidly renewable source – the leaves of the *Indigofera tinctoria* plant – it is often derived from petrochemical sources which are non-renewable. During the manufacturing stage, circularity issues are associated with wasteful use of toxic dye auxiliaries needed for the dyeing process. There is the possibility of residual aniline, a possible carcinogen, remaining as a contaminant in the dye and therefore the fabric after it has been manufactured. However, this may be removed during the garment washing stage. Lastly, there are potential issues with circularity related to the end-of-use of the garment containing indigo dye. Often, indigo dye is washed off a garment before the fabric is recycled or reused. However, because indigo is not very biodegradable, this pathway will not result in closing of the material loop.

## + Why was **indigo** chosen for the Call to Innovation?

Pre-reduced indigo was chosen for the Call to Innovation to complement a trend toward green innovation in the denim industry. Many brands are developing more sustainable jeans by adopting organic cotton and using less water and energy during garment washing. However, denim needs to be enhanced with sustainable dyes such as pre-reduced indigo and other sulfur dyes that use inherently safer chemicals during their manufacture and application.

Indigo is sold either as a powder or a liquid in its reduced state. The liquid indigo is called pre-reduced indigo, and it has the following sustainability attributes that make it a good candidate for *Cradle to Cradle Certified GOLD* level certification.

- + It is reduced by the chemical company rather than the mill so significantly less effluent is produced.
- + It is safer for workers and the environment.
- + It does not contain residual amounts of aniline because the indigo is thoroughly washed during the manufacturing process, removing residual aniline from the dye.

## + What is the action plan for **indigo dye** through Call to Innovation?

Fashion Positive PLUS members have identified pre-reduced indigo from DyStar Group as a candidate for further assessment. DyStar's pre-reduced indigo has already earned a GOLD level material health certificate from *Cradle to Cradle Certified*. Rising to the call for circular material innovation, the pre-reduced indigo dye will be further optimized and earn a full product certification.

## + What's exciting about priming **indigo dyes** as an input for the circular economy?

More indigo is produced than any other dye in the world. The denim industry has embraced sustainability as a platform for innovation, though prior to now, most of the innovation work is occurring either at the fiber stage (e.g., organic cotton or Tencel blended with cotton) or garment finishing (e.g., waterless techniques) part of the supply chain.