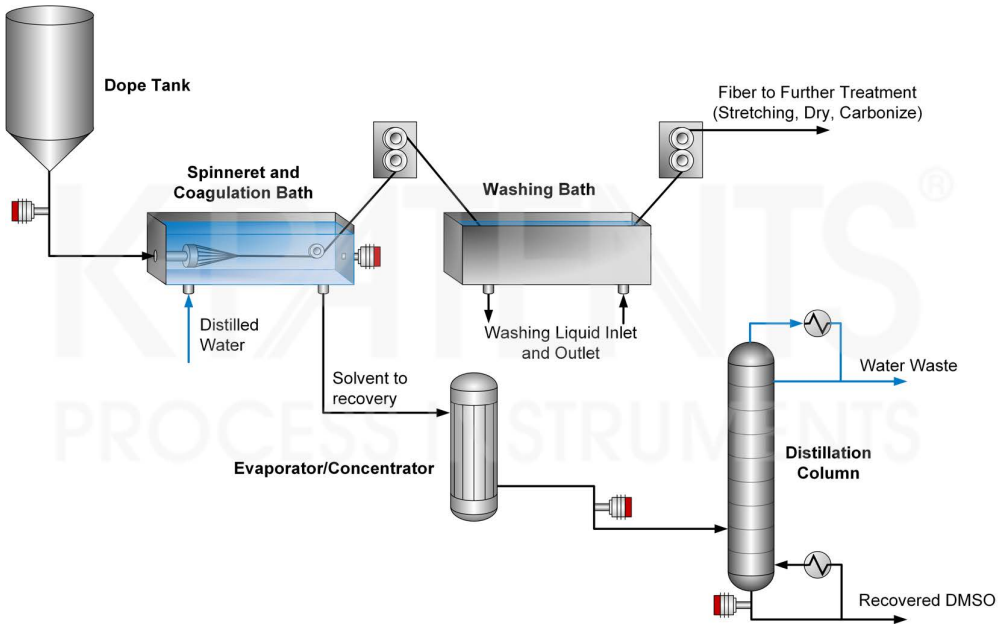
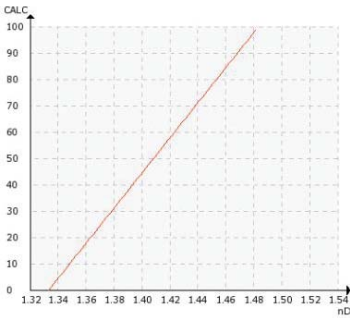


DIMETHYL SULFOXIDE (DMSO), DIMETHYL FORMAMIDE (DMF) AND DIMETHYL ACETATE (DMAC)

Typical end products

Carbon fibers for different applications such as aerospace, sporting goods, wind tubine blades, automotive.

Chemical curve: Dimethyl Sulfoxide R.I. per % b.w. at Ref. Temp. of 20˚C



Introduction

Carbon fiber is a long, thin strand of material that contains over 90 % of carbon by weight. The raw material used to make carbon fiber is known as *the precursor*.

Carbon fibers are obtained by pyrolysis of an appropriate precursor fiber. Polyacrylonitrile (PAN) is the predominant precursor for carbon fiber due to a superior strength and stability, and higher carbon yield. About 90 % of the carbon fiber produced is made from PAN and the remaining 10 % is made from rayon or petroleum pitch.

PAN-based carbon fiber is widely used in many industries such as aviation, aerospace, sporting goods, and construction.

Application

The first step in the production of PAN-based carbon fibers is spinning the PAN co-polymer to form the fibers. Because PAN decomposes before melting, it is necessary to make a spinning solution or *dope solution* with a solvent in order to be able to spin the material into a fiber. Common solvents are dimethyl sulfoxide (DMSO), dimethyl formamide (DMF), dimethyl acetate (DMAc) and sodium thiocyanate. The concentration of the dope solution is usually 15-25 wt-% and should be carefully controlled to ensure its ability to form filaments of high mechanical strength.

Spinning can be done through different methods, such as dry-jet wet spinning or wet spinning. However, only the wet spun PAN fiber is used as a precursor for carbon fiber, as it contains a co-polymer (e.g. itaconic acid) that helps the carbonation process.

In wet spinning, the dope solution is passed through a *spinneret* into a coagulation bath to form filaments.

The fibers solidify when the solvent diffuses away, leaving behind the PAN fibers.

The spinning step is important because the internal atomic structure of the fiber is formed during this process. The quality of the final fiber depends on different process parameters, such as the composition of the dope and the temperature and concentration of the coagulation bath.

After the fibers are formed, they are further treated by stretching, stabilization, carbonation and graphitization. The final carbon fiber is then ready for its use in different applications. The solvent-water mixture from the coagulation bath is sent to the recovery area where water and solvent are separated. The recovered solvent is used again in the dope preparation to save operating costs.

Instrumentation and installation

The K-Patents Process Refractometer PR-43-GP monitors in-line the concentration of solvent at different stages of the process.

The refractometer is installed directly on the pipe after the dope tank to measure the concentration of the PAN solution before it is pumped into the coagulation bath. The real-time information by the K-Patents refractometer helps to maintain the dope concentration within the desired range and to obtain precursor fibers with excellent properties.

As the fibers are formed and passed through the coagulation bath, the solvent diffuses out changing the concentration of the bath. The K-Patents refractometer monitors continously the solvent concentration in the bath, and provides real-time information to keep the concentration at its optimal by the addition of water.

At the solvent recovery stage, the refractometer monitors the concentration after evaporation and distillation. The refractometer provides Ethernet and 4-20 mA output signals that can be used as feedback for automated control. The instant and accurate measurement from the refractometer ensures the target concentration is always achieved while reducing the energy costs.

The K-Patents refractometer reduces the need for sampling and laboratory tests. The refractometer is factory calibrated and does not require re-calibration. Automatic prism wash may be needed in this application.

Instrumentation	Description
	K-Patents Process Refractometer PR-43-GP is a general industrial refractometer for pipes and vessel installations. The PR-43-GP can be installed with 2, 3 and 4 inch flange and 3 inch Sandvik L coupling process connections and a variety of flow cells for pipe sizes of 1 inch and larger.
User Interface	Selectable multichannel MI, compact CI or a web-based WI user interface options allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data.
Measurement range	Refractive Index (nD) 1.3200 – 1.5300, corresponding to 0-100 % by weight.