Application Note AN-PAN-1008

Online analysis of sulfuric acid in the cumene process (phenol production)

Phenol is a versatile base material utilized to produce a vast range of compounds, such as polymers (e.g., polycarbonates and epoxies), synthetic fibers (e.g., nylon), and resins (e.g., bisphenol A). These are widely used in textiles, plywood, and countertops, plastics for appliances and electronics, and materials for adhesives. Phenol also serves as a raw material for detergents, herbicides, and pharmaceuticals. Medicinally, it acts as a disinfectant and antiseptic [1].

More than 90% of phenol worldwide is made from cumene, using the cumene hydroperoxide route [2]. A crucial step in that process is the acid cleavage of this peroxide, i.e., its decomposition to acetone and phenol [2,3].

This Process Application Note demonstrates the use of the 2060 TI Process Analyzer or the 2035 Process Analyzer for potentiometric titration of sulfuric acid in the cumene process, to enable strict control of its concentration so that high phenol quality is obtained afterward.

INTRODUCTION

Several methods have been developed for phenol production due to its commercial importance. Most phenol is produced by the so-called «cumene process», based on the autocatalytic cumene oxidation and dilute acid cleavage of the formed cumene hydroperoxide (CHP).

The cumene process (or Hock process) has three stages:

1. production of cumene from benzene and propylene
2. conversion of cumene to cumene hydroperoxide
3. decomposition (cleavage) of preconcentrated cumene hydroperoxide to phenol and acetone

Small amounts of sulfuric acid (H_2SO_4) are used to catalyze the reaction in the last stage. Since the cleavage reaction is very unstable, the decomposition reactor (Figure 1) must be operated under strict temperature and acidity control with a high level of acetone reflux [2].

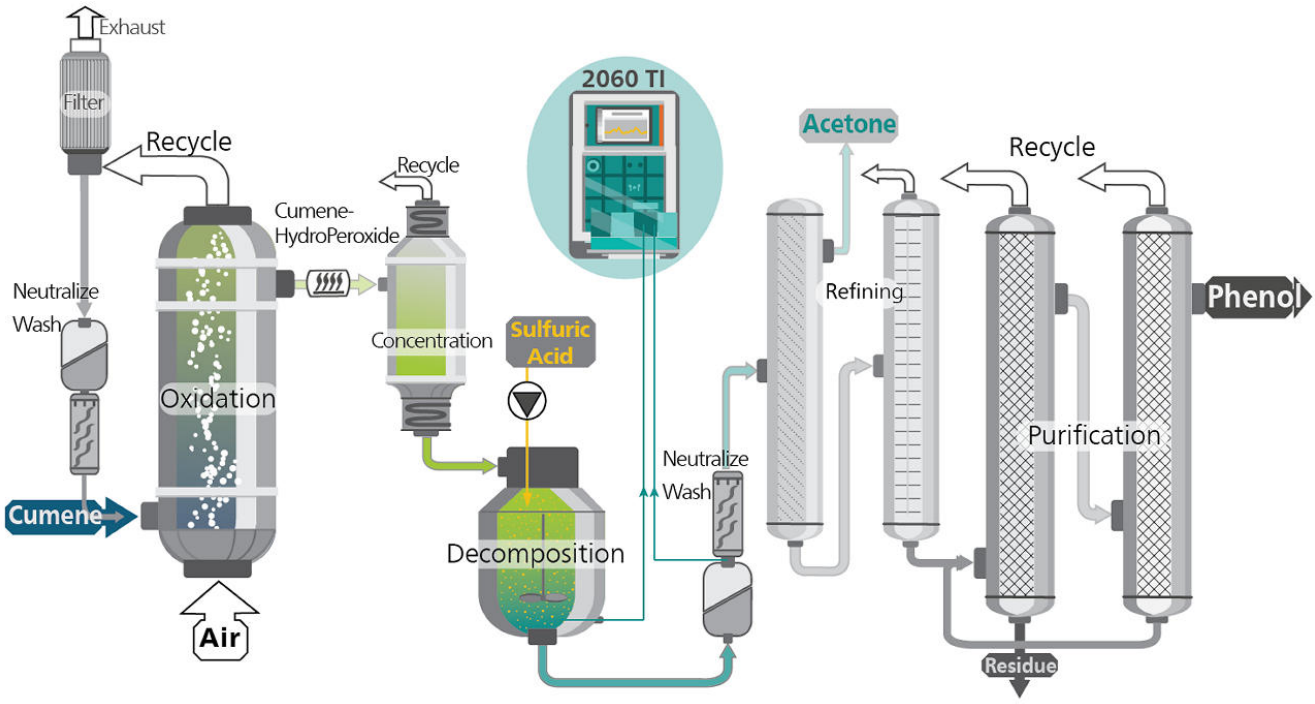

Figure 1. Simplified schematic showing how phenol is produced from cumene.

In practice, many side reactions take place simultaneously with the reactions shown in Figure 2. Dimethylphenylcarbinol (DMPC) is the main oxidation byproduct, which reacts further in the acidic medium to α-methylstyrene (AMS). AMS can be a desired byproduct or can be recycled back to the cumene feed stage. Recycle loops are present at various places for process optimization (Figure 1).
Besides controlling various byproducts, preventing the formation of color bodies and corrosion is also extremely important. Therefore, it is necessary to remove traces of sulfuric acid prior to downstream distillation and purification. Thus, accurate and online measurement of sulfuric acid plays an important role in the overall cumene production process.

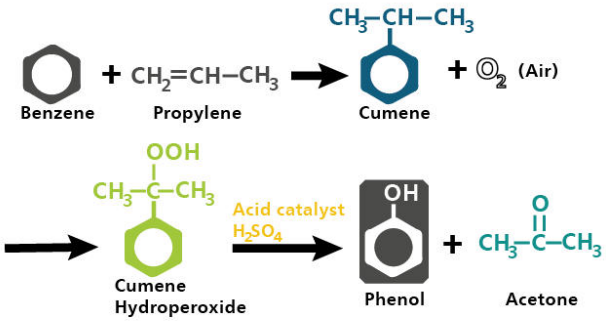

Figure 2. Overall reaction mechanism for the cumene process

APPLICATION

Sulfuric acid is analyzed online using potentiometric titration. It is measured in the decomposition stream and in other downstream production stages. High precision and simple validation are achievable using the titration method, which is an acknowledged reference and absolute measuring technique.

Process Stage	Range [mg/L H_2SO_4]
Decomposition	0–40
Downstream	0–350

REMARKS

In hazardous explosive environments, process analyzers must be fit for explosion-proof utilization. The 2060 TI EX Proof Process Analyzer (Figure 3) from Metrohm Process Analytics is ATEX certified (2014/34/EU). It is functionally the same as a 2060 TI Process Analyzer, but has a full stainless-steel cabinet, all the necessary electric intrinsically safe isolators and barriers, and is provided with an EX-P purge system.

Figure 3. The 2060 TI EX Proof Process Analyzer from Metrohm Process Analytics.

CONCLUSION

The Metrohm Process Analytics 2060 TI EX Proof Process Analyzer can accurately measure the concentration of sulfuric acid in phenol production online, facilitating optimized production, improved quality, and reduced chemical consumption.

REFERENCES

1. *Phenol - Chemical Safety Facts.* https://www.chemicalsafetyfacts.org/chemicals/phenol/ (accessed 2025-10-02).
2. Schmidt, R. J. Industrial Catalytic Processes—Phenol Production. *Applied Catalysis A: General* **2005**, *280* (1), 89–103. DOI:10.1016/j.apcata.2004.08.030
3. Engineers Guide: Cumene Peroxidation Process for Phenol Production. *Engineers Guide*.

BENEFITS FOR ONLINE PROCESS ANALYSIS

- **Optimize product quality** and increase profit with fast response times for process variations.
- **Fully automated diagnostics** – automatic alarms for when samples are out of specified parameters.

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CONFIGURATION

Appareil d'analyse de processus 2060 TI Ex-Proof

L'appareil d'analyse de processus 2060 TI Ex-Proof est un appareil d'analyse de processus par chimie humide de sécurité intrinsèque destiné au contrôle des processus dans les environnements dangereux gazeux ou poussiéreux classés en zones 0, 1 et 2, ou 20, 21 et 22. Conforme aux directives UE 94/9/CE (ATEX95) et certifié pour les zones 1 et 2, il associe un système de purge et de pressurisation à des dispositifs électroniques de sécurité intrinsèque. La phase de purge d'air et la surpression permanente empêchent la pénétration d'atmosphères potentiellement explosives dans l'enveloppe de l'appareil d'analyse.

Sa conception élimine le besoin de purger les grands abris d'analyse, permettant une installation directe sur la ligne de production en zone dangereuse. Il prend en charge diverses techniques, notamment le titrage, le titrage Karl Fischer, la photométrie, les mesures par électrode ionique spécifique et les mesures directes.