A172 Product Process Troubleshooting Guide

Contents

service system and can supply A172 from multiple well-known original manufacturers. As a research & development-oriented new foreign trade service provider, HiSiaddi sorts out key points requiring attention for A172 product process troubleshooting from a professional perspective and shares them with you.

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I. Troubleshooting of Raw Material and Auxiliary Material Section

1.1 Troubleshooting of Abnormal Core Synthetic Raw Materials

1. Vinyltrichlorosilane ($ViSiCl_3$): Insufficient raw material purity containing Si-H hydrosilane, polychlorosilane and low-molecular siloxane impurities generates hydrosilane by-products and cyclic siloxanes during alcoholysis, resulting in reduced main peak purity of finished products and severe attenuation of interfacial coupling adhesion strength; excessive water content in raw materials undergoes rapid hydrolysis upon contact with water to form silanol, causing massive self-polymerization in the system to produce white gel flocs, blocking conveying pipelines and lowering product light transmittance; long-term storage of raw materials releases hydrogen chloride, corroding storage tanks and introducing iron and aluminum metal ions, leading to yellowing of finished products during long-term storage and deteriorated metal corrosion resistance; insufficient vinyl purity of raw materials containing saturated alkyl impurities reduces crosslinking activity and lowers curing and crosslinking efficiency of rubber, plastic and coating systems.
2. Anhydrous Methanol: Excessive water content destroys the anhydrous primary alcoholysis system, triggering hydrolysis to form silanol and polymerization with elevated oligomer impurities; formic acid, aldehyde impurities in methanol induce free radical polymerization of vinyl groups via high-temperature transesterification, causing material yellowing and formation of viscous gel substances; unbalanced methanol feeding ratio leads to incomplete chlorine substitution with excessive residual chloride ions when methanol is insufficient, while excessive methanol increases rectification light fraction load and aggravates pungent VOC odor.
3. Ethylene Glycol Monomethyl Ether (2-Methoxyethanol): Insufficient purity containing diethylene glycol methyl ether and high-boiling alcohol

impurities generates polyalkoxy hybrid silanes via transesterification, resulting in disordered boiling point range of finished products and deteriorated hydrolysis stability; water contained in raw materials reversely shifts the transesterification equilibrium, lowering target product yield and leaving unsubstituted methoxysilane residues; peroxide impurities in raw materials trigger polymerization of vinyl double bonds, generating macromolecular viscous polymers in the system and intensifying filtration loss.

1.2 Troubleshooting of Catalytic and Neutralization Auxiliaries

1. Acid-base transesterification catalysts (sodium hydroxide, p-toluenesulfonic acid, sodium alkoxide): Insufficient dosage of alkaline catalysts leads to incomplete transesterification with massive residual vinyltrimethoxysilane intermediates and poor coupling performance; excessive alkali creates a strongly alkaline system to induce free radical polymerization of vinyl double bonds, causing yellowing and thickening of materials, while siloxane bonds hydrolyze to form silanol oligomers; excessively high concentration of acidic catalysts catalyzes silane hydrolysis and polycondensation to produce cyclic D3, D4 siloxane impurities and aggravates chloride corrosion; fine solid catalyst particles fail to be completely separated by filtration, leaving suspended white spots and excessive ash content in finished products.
2. Neutralization buffers (sodium bicarbonate, glacial acetic acid): Excessively alkaline pH at neutralization end point leaves residual free alkali that continuously catalyzes silane hydrolysis, resulting in stratification and turbidity during storage; excessively acidic pH retains hydrochloric acid and organic acids, with chloride ions causing long-term pitting corrosion on metal substrates in coatings and adhesives; heavy metal impurities contained in buffer salts precipitate salt speckles after high-temperature baking, failing appearance requirements of transparent coatings.
3. Polymerization inhibitors (hydroquinone, phenothiazine): Insufficient dosage triggers spontaneous polymerization of vinyl groups under heat and oxygen, generating macromolecular gel particles and causing turbidity of finished products as well as heavy filtration loss; excessive inhibitor dosage leads to precipitation, forming yellow stain spots on coatings after high-temperature curing and limiting applications in electronic and photovoltaic materials.

1.3 Troubleshooting of Refining Auxiliaries

1. Extraction and dilution solvents (toluene, isopropanol): Recycled solvents accumulate silane oligomers and colored gels, continuously contaminating batches when recycled for feeding; water contained in solvents triggers silane hydrolysis with rising impurity base values; excessive residual high-boiling solvents result in slow drying of finished products and generation of bubbles and pinholes on cured paint films.
2. Decolorizing activated carbon: High ash content and mismatched adsorption pore size fail to remove yellow organic gels generated by vinyl polymerization; excessively fine carbon powder particles remain as black micro-particles after precision filtration, causing defects in high-end transparent adhesives and photoresist adhesion promoters.
3. Process nitrogen and process pure water: Excessive oxygen content in nitrogen induces oxidative polymerization of double bonds under high temperature and causes material yellowing; excessive ions and chloride ions in pure water trigger rapid silane hydrolysis during water washing, generating massive flocculent siloxane precipitates and severe loss of product yield.

II. Troubleshooting of Primary Alcoholysis (Vinyltrimethoxysilane Intermediate) Section

2.1 Malfunctions of Material Ratio and Dropwise Feeding Process

Unbalanced molar ratio of $ViSiCl_3$ to anhydrous methanol leads to incomplete chlorine substitution when methanol feeding is insufficient, with excessive total chlorine and hydrolyzable chloride ions in finished products causing corrosion failure of metal substrates; excessive methanol leaves large amounts of free methanol in the system, resulting in residual light fractions after rectification and pungent odor of finished products; rapid concentrated dropwise addition of methanol releases massive hydrogen chloride locally in an instant, and the acidic environment catalyzes silane hydrolysis and polymerization to form white gels; fluctuating dropwise feeding rate causes dramatic reaction temperature swings, leading to scattered intermediate purity across batches and unstable subsequent transesterification indicators.

2.2 Abnormal Control of Temperature, Negative Pressure and Stirring

Standard alcoholysis temperature control range is 75～85℃. Temperature below 70℃ leads to insufficient alcoholysis activation and low chlorine substitution conversion rate; temperature above 90℃ causes volatilization loss of $ViSiCl_3$ raw materials, while high temperature triggers vinyl polymerization and material yellowing; insufficient negative pressure inside the reactor fails to timely extract by-product hydrogen chloride, maintaining

persistent acidity in the system and inducing silane hydrolysis and polycondensation to form cyclic siloxane impurities; stirring failure causes material stratification with stagnant reaction of bottom raw materials and localized high-temperature polymerization to form gel on the upper layer; excessively fast stirring entraps large volumes of air to induce oxidative generation of colored impurities from double bonds and reduce light transmittance of intermediates.

2.3 Failures of Sealed Anhydrous Protection

Incomplete nitrogen replacement or air leakage and water ingress during feeding and reaction stages, coupled with water contained in methanol or external water vapor entering the system, generates massive silanol with rapid self-polymerization, forming viscous gel masses inside the reactor, blocking filtration and drastically reducing intermediate yield; failure of hydrogen chloride tail gas recovery system causes backflow of acidic gas into the reactor, continuously aggravating side hydrolysis reactions.

III. Troubleshooting of Secondary Transesterification (A172 Main Reaction) Core Section

3.1 Malfunctions of Material Ratio and Catalyst Feeding

Unbalanced molar ratio of vinyltrimethoxysilane intermediate to ethylene glycol monomethyl ether leads to incomplete transesterification substitution when ethylene glycol methyl ether feeding is insufficient, leaving massive trimethoxy intermediates and lowering coupling activity and hydrolysis resistance; excessive feeding leaves residual high-boiling alcohol, increasing distillate loss at the tail of rectification and raising boiling point of finished products; one-time concentrated feeding of catalysts causes localized overloaded acid-base concentration, instantly triggering vinyl polymerization and siloxane hydrolysis to rapidly turn the system turbid and viscous; uneven catalyst dispersion results in excessive transesterification in partial reactor zones and stagnant reaction in others, leading to huge purity differences of products across batches.

3.2 Abnormal Working Conditions of Temperature and Negative Pressure for Methanol Removal

Standard transesterification temperature control range is 90～105℃. Temperature below 90℃ slowly pushes forward the reversible transesterification equilibrium with low substitution conversion rate; temperature above 110℃ induces two types of side reactions: free radical polymerization of vinyl double bonds to generate macromolecular gels and hydrolysis polycondensation of silane alkoxy groups to form oligomeric

siloxanes, deepening chroma of finished products and lowering main peak purity; insufficient vacuum negative pressure inside the reactor fails to continuously remove by-product methanol, shifting the reversible reaction backward and continuously reducing target product yield; fluctuating negative pressure causes methanol to reflux into the reactor, repeatedly elevating alcohol concentration in the system and continuous accumulation of impurities.

3.3 Failures of Polymerization Inhibition and Sealed Protection

Insufficient polymerization inhibitor dosage or lack of supplementary addition during the process leads to continuous vinyl polymerization under high temperature and oxygen-containing environment, forming yellowish-brown gel polymers adhering to reactor walls and cross-contaminating subsequent batches; failure of nitrogen isolation allows continuous air ingress into the reactor to generate peroxide impurities, accelerating silane degradation and material yellowing; insufficient reaction duration fails to reach transesterification equilibrium with excessive residual intermediates; overlong heat preservation causes long-term high-temperature aging of materials and sharp rise of hybrid silane impurity content.

IV. Troubleshooting of Neutralization, Water Washing and Desalting Crude Separation Section

4.1 Malfunctions of pH End Point Control in Neutralization

Neutralization end point pH＜4.0 leaves massive residual hydrochloric acid, organic acids and catalyst ions in the system, continuously catalyzing silane hydrolysis during long-term storage to cause liquid stratification and turbidity with elevated risk of chloride corrosion; weakly alkaline environment with pH ＞7.0 triggers rapid hydrolysis and bond breaking of A172 alkoxy groups, loss of effective components and severe attenuation of coupling performance; one-time large-volume feeding of neutralization buffer leads to saturated local salt concentration and precipitation of white silicate microcrystals, leaving suspended white spots in finished products.

4.2 Failures of Water Washing Stratification and Desalting

Insufficient water washing times leave sodium chloride and organic salts generated by reactions in the organic phase, causing salt scaling to block packed towers under high temperature during rectification, as well as excessive ash content in finished products and salt precipitation whitening defects on cured coatings; excessively low water washing temperature thickens silane organic phase with blurred oil-water interface, resulting in massive product retention in water phase and severe yield loss; insufficient

standing stratification duration carries fine salt colloids into the rectification process to generate colored silicate impurities under high temperature.

4.3 Failures of Coarse Filtration for Gel Removal

Excessively large pore size or damaged leakage of coarse filter screens allows gel micro-masses generated during alcoholysis and transesterification to enter the rectification system, undergoing continuous polymerization under high temperature to precipitate flocculent precipitates after long-term standing of finished products; blocked filter screens retain materials inside the reactor for sustained high-temperature aging, gradually deepening chroma of each batch.

V. Troubleshooting of High-Vacuum Rectification, Light and Heavy Component Removal Purification Section

5.1 Abnormal Vacuum Degree and Rectification Temperature

Insufficient rectification vacuum degree and excessively high tower top temperature fail to completely remove light components such as free methanol and unreacted ethylene glycol methyl ether, resulting in pungent VOC odor of finished products and bubble generation on cured paint films; excessively high tower bottom temperature causes thermal degradation of heat-sensitive vinyl groups and alkoxy groups of A172 via dealcoholization and double bond polymerization, lowering main peak purity and sharply increasing high-boiling gel impurities; vacuum leakage allows oxygen ingress to induce oxidative yellowing of feed liquid under high temperature and drastically reduce light transmittance.

5.2 Malfunctions of Reflux Ratio and Distillate Cutting

Excessively small reflux ratio fails to effectively separate trimethoxy intermediates and light alcohol impurities, leading to unstable coupling performance of finished products; excessively large reflux ratio prolongs high-temperature residence time of materials to intensify thermal degradation and yield loss; offset distillate cutting interval mixes front-end light impurities into main products and entraps tail-end high-boiling polymeric gels, simultaneously reducing hydrolysis resistance and adhesion strength of finished products; premature cutting retains effective components at the bottom of the tower with drastically reduced single-batch yield.

5.3 Failures of Tower Salt Scaling and Air Tightness

Salt residues left from water washing accumulate on packing surfaces to form salt scales, unbalancing gas-liquid mass transfer and continuously deteriorating rectification separation precision with violent fluctuations of batch purity and chlorine content; air leakage of equipment flanges and packing

seals allows continuous oxygen ingress into the tower, inducing silane oxidation to generate yellow impurities and failing appearance requirements of finished products.

VI. Troubleshooting of Decolorization, Precision Filtration and Low-Temperature Maturation Section

6.1 Abnormal Activated Carbon Decolorization Process

Excessively high decolorization temperature and overlong heat preservation duration cause activated carbon to adsorb target silane components, resulting in product yield loss and slight decline of coupling activity; insufficient decolorization parameters fail to remove yellow gels generated by vinyl polymerization, leaving liquid with yellow base color; open decolorization contact with air triggers secondary oxidation and chroma rebound; insufficient precision or damaged leakage of precision filter elements leaves black suspended micro-particles in finished products, causing appearance defects in photovoltaic and transparent adhesive materials.

6.2 Malfunctions of Filtration and Maturation Stabilization

Excessively low filtration temperature elevates material viscosity to reduce filtration flux, failing to completely intercept gel micro-masses and salt colloids; high-temperature and light-exposed maturation workshop environment induces slow vinyl oxidation and trace hydrolysis of alkoxy groups, leading to slight viscosity drift of finished products during storage and attenuation of adhesion strength.

VII. Troubleshooting of Filling Sealing and Finished Product Storage Stability Hidden Dangers

1. Long-term storage temperature＞25℃: High temperature accelerates slow vinyl polymerization and alkoxy hydrolysis polycondensation, gradually turning finished liquid turbid, lowering main peak purity and continuously attenuating interfacial adhesion strength with rubber, plastic and inorganic fillers.
2. Direct light exposure: Ultraviolet rays induce free radical polymerization via photooxidation of vinyl groups to generate macromolecular gels, turning colorless transparent liquid pale yellow and causing matting and pinhole defects on cured coatings.
3. Excessively high environmental humidity and air/water ingress through poor packaging sealing: Trace water continuously catalyzes silane hydrolysis to generate silanol oligomers, leading to stratification and precipitation of white flocculent precipitates after long-term storage.

4. Cross-contamination from mixed storage: Co-storage with strong acids, strong alkalis, oxidants, alcohol solvents and amines triggers rapid hydrolysis and double bond polymerization of A172, completely invalidating coupling functions and generating pungent irritant odors.
5. Unqualified container materials: Ordinary carbon steel barrels rust to precipitate iron ions, catalyzing silane hydrolysis and polymerization and drastically shortening shelf life; transparent plastic barrels transmit light to accelerate yellowing, while inferior liners leach plasticizers to form unknown impurity peaks in electronic adhesives and photoresist additives.

VIII. Full-Process Traceability Troubleshooting for Abnormal Finished Product Testing

8.1 Traceability of Low Main Peak Purity and Excessive Residual Trimethoxy Intermediates

Incomplete chlorine substitution in primary alcoholysis → insufficient ethylene glycol methyl ether ratio and insufficient heat preservation duration in transesterification → insufficient precision of front-end cutting in rectification → reverse transesterification reaction under high-temperature storage.

8.2 Traceability of Yellow/Turbid Liquid with White/Black Micro-Particles

Raw material oxygen and water content induce hydrolysis and polymerization → insufficient polymerization inhibitor generates yellow gels under high-temperature reactions → incomplete desalting via water washing precipitates salt crystals → residual carbon powder and gel micro-masses after decolorization and filtration.

8.3 Traceability of Excessive Chloride Ions, Ash Content and Substrate Corrosion

Failure to timely extract hydrogen chloride during alcoholysis → missing neutralization and water washing desalting procedures → incomplete filtration separation of catalysts and buffer salts → tower salt scaling carried into finished products during rectification.

8.4 Traceability of Poor Adhesion Strength and Unstable Coupling Performance

Elevated oligomeric siloxane impurities → excessive residual trimethoxy intermediates → macromolecular vinyl polymeric gels interfering with interfacial bonding → self-polymers generated by silane hydrolysis during storage.

8.5 Traceability of Pungent VOC Odor and Curing Bubble/Pinhole Defects

Excessive residual methanol and ethylene glycol methyl ether light components → insufficient vacuum and low temperature for light component removal during rectification → offset front-end distillate cutting interval.

8.6 Traceability of Sustained Low Batch Yield

Gel filtration loss from rapid methanol dropwise addition in alcoholysis → interception of macromolecular polymeric gels generated during transesterification → excessive tail-end distillate cutting loss of main products → organic phase loss during water washing stratification.

IX. Rapid Segmented Troubleshooting Process for Batch Abnormalities

1. Single-batch abnormality localization: Lock purity and water content of $ViSiCl_3$, methanol and ethylene glycol methyl ether raw materials, temperature-pressure dropwise feeding parameters of primary alcoholysis, catalyst and polymerization inhibitor dosage in transesterification matching ratio, neutralization water washing desalting working conditions, rectification distillate cutting, decolorization filtration and filling operation deviations.
2. Full-line persistent abnormality localization: Failure of pre-processing quality control for anhydrous and deoxygenated raw materials, negative pressure hydrogen chloride removal closed system for alcoholysis, temperature-controlled polymerization inhibition protection unit for transesterification, multi-stage water washing desalting system, high-vacuum rectification equipment, light-proof low-temperature low-humidity storage system.
3. Segmented sampling fault localization: Alcoholysis trimethoxy intermediate → crude transesterification product → organic phase after neutralization water washing → pre-rectification/main/tail distillates → decolorized filtered finished products; segmentally test GC main peak purity, chloride ions, chroma, viscosity and light component residues to lock faulty sections.
4. Equipment verification: Stability of temperature control, negative pressure and tightness of alcoholysis negative pressure reactor, temperature-controlled closed transesterification reactor, neutralization water washing stratification equipment, high-vacuum rectification tower, activated carbon precision filtration and light-proof sealed filling equipment.
5. Auxiliary material re-inspection: Purity and water content of vinyltrichlorosilane, impurity content of methanol/ethylene glycol methyl

ether, catalyst activity, polymerization inhibitor purity, decolorization capacity of activated carbon, oxygen content of process nitrogen.

6. Small-scale test verification: Standardized low-temperature uniform-speed alcoholysis, temperature-controlled polymerization-inhibited transesterification, multi-stage neutralization water washing desalting and precise vacuum rectification process to reproduce abnormalities, distinguish root causes of raw material defects, auxiliary material failure or out-of-control process parameters.

X. Core Process Control Red Lines for the Entire Process

1. Raw material pre-process red line: Strictly control purity, water content and peroxide impurities of vinyltrichlorosilane, methanol and ethylene glycol methyl ether; prohibit feeding of water-containing and oxidized deteriorated raw materials; implement full-process nitrogen oxygen-isolated anhydrous protection for alcoholysis and transesterification to inhibit generation of hydrolysis gels and vinyl polymerization by-products from the source.
2. Primary alcoholysis red line: Stabilize temperature control range of 75～85℃, add methanol dropwise at uniform speed and continuously remove hydrogen chloride under negative pressure to ensure complete chlorine substitution, control basic chloride ion content and reduce subsequent desalting pressure.
3. Core transesterification red line: Precisely match feeding molar ratio of ethylene glycol methyl ether, stabilize reaction temperature of 90～105℃, add sufficient polymerization inhibitor to suppress double bond polymerization, continuously remove by-product methanol under negative pressure to drive forward substitution and raise main peak purity of target products.
4. Neutralization water washing red line: Precisely control neutral end point within neutral range, fully remove all inorganic salts and free acids/bases via multi-stage warm water washing to eliminate hidden dangers of salt precipitation, chloride corrosion and later hydrolysis stratification.
5. Rectification purification red line: High-vacuum low-temperature rectification, reasonably control reflux ratio, precisely cut main distillates, completely remove light alcohol impurities and high-boiling polymeric gels, balance three major indicators of product purity, low chloride and low VOC.

6. Decolorization filtration red line: Low-temperature short-time activated carbon refined decolorization, multi-stage precision filtration to fully intercept carbon powder, gel micro-masses and salt crystals, guarantee colorless transparent finished products free of suspended impurities with excellent light transmittance.
7. Filling and storage red line: Light-proof sealed barrels lined with stainless steel/corrosion-resistant PE for airtight filling; constant-temperature storage ≤25℃, fully light-proof, independent partition storage with humidity 40%–60%, prohibit mixed storage with strong acids, strong alkalis, oxidants, alcohols and amines.
8. Quality bottom line: Strictly control six core risks including insufficient main peak purity, excessive chloride ions, yellow/turbid liquid, residual light component VOC, attenuation of coupling performance and stratification/precipitation during storage; finished silane coupling agent A172 is colorless transparent low-viscosity liquid with stable vinyl activity, low chloride ions and excellent hydrolysis resistance, delivering outstanding adhesion improvement effect on glass fiber, inorganic fillers and metal substrates, applicable to industrial scenarios such as vinyl resin, rubber plastic crosslinking, photovoltaic adhesives, coating adhesion promotion, photoresist additives and inorganic filler surface treatment.

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