Industrial organic wastewater treatment with high COD, high salt, high ammonia nitrogen, high toxicity, and low biodegradation, without secondary pollution

WORLDIA®

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BORON-DOPED DIAMOND

WORLDIA BDD ELECTRODES AND MODULE

BDD(Boron Doped Diamond)——Optimum Electrode Materials of Electrochemical Advanced Oxidation Processes

BEIJING WORLDIA DIAMOND TOOLS CO.,LTD.

WORLDIA

Technological pioneer of niobium-based BDD electrodes and reactors in China

Independently developed equipment with three-chamber,
enabling simultaneous production on both sides of BDD electrodes.

CONTENTS

WORLDIA

INTEGRITY VALUE PEAK

FOCUS ON HIGH-END TOOLS AND NEW MATERIALS MANUFACTURING
SHAPING THE WORLD'S QUALITY

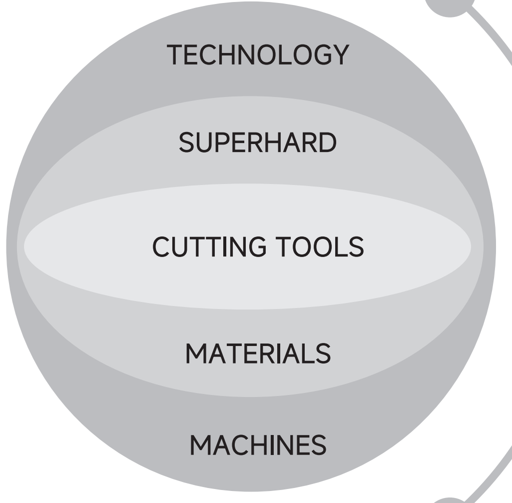
WORLDIA

One of first 25 companies listed in China STAR Stock Market in 2019.
(Stock Code: 688028)

315 patents, including 84 invention patents
(as of December 2024)

Globally 1400 employees

High-tech and innovation



01 Laser micro-nano precision processing technology of superhard materials

- Infrared laser, green laser, ultraviolet laser
- Cutting process
- Grinding process

02 CVD diamond functional material growth and application technology

- CVD diamond functional materials for semiconductors and other use
- CVD lab-grown diamond (gem grade)
- Scientific research

03 Ultra-thin diamond blank, composite die precision grinding and mirror polishing technology

- Ultra-thin (0.05mm) diamond blanks
- ±1 μm accuracy
- Double-sides polishing

04 Customized and advanced coating technology

- PVD coating
- CVD coating
- Diamond coating

05 Ultra-high precision, high-precision superhard tool manufacturing and application technology

- PCD/MCD/CVDD superhard tools
- PCBN superhard tools
- High-precision superhard tools

06 Automation equipment development technology

- Laser cutting machine
- Mirror polishing machine
- CVD growth equipment
- CNC laser sharpening machine
- Laser engraving machine
- Automation auxiliary equipment

Technology and innovation have always been our inspiration since the company was founded in 2000. As we keep learning from the challenging requirements of our global customers, product quality and performance have made significant progress. Customers have enhanced their competitive position in the industry worldwide by using our products.

Made-in-China going global

- Building area greater than 100,000 square meters
- Imported manufacturing and testing equipment, manufactured or independently developed by Switzerland, Germany, the United States, and Japan
- ISO 9001/GB/T 19001
  ISO 14001/GB/T 24001
  ISO 45001/GB/T 45001

Core Technology

Preparation of diamond by CVD method

CVD (Chemical Vapor Deposition): The process of generating solid deposits by reacting gaseous or vapor substances at the gas phase or gas-solid interface.
Worldia is one of the few companies in China that can master CVD (chemical vapor deposition) diamond growth technology (hot wire CVD, DC CVD, microwave CVD) and implement industrial production of products.

Microwave plasma CVD (MPCVD)

Microwaves are used to excite carbon-containing gases (such as H_2/CH_4) to form high-density plasma, which efficiently decomposes carbon sources. Its active carbon groups (such as CH_3) have high concentration and are evenly distributed, as well as highly ordered deposition, which can effectively inhibit the generation of impurities and non-diamond phases, and is suitable for the preparation of high-quality single crystal/polycrystalline diamond.

Hot filament CVD (HFCVD)

Carbon-containing gases (such as H_2/CH_4/ethanol) are pyrolyzed by high-temperature hot filaments (commonly used tungsten filaments or tantalum filaments). Compared with MPCVD, HFCVD is prone to introduce metal contamination and non-diamond phase defects, but it has a large deposition area, simple equipment, and low cost, and is more suitable for large-scale production of polycrystalline diamond.

DC arc plasma jet (DC-PJ CVD)

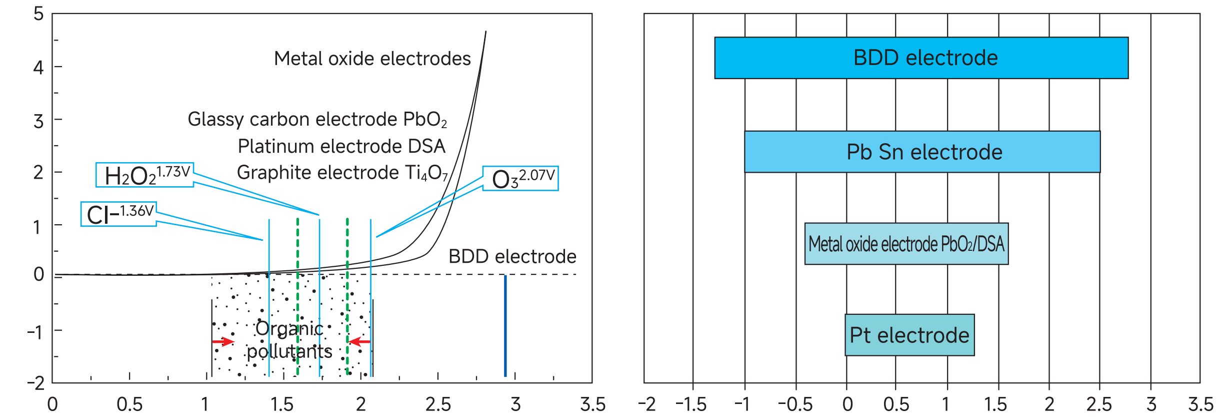
A high-temperature plasma jet (3000–5000°C) is formed by ionizing carbon-containing gases (such as $Ar/H_2/CH_4$) with a DC arc, and the high-speed impact on the substrate achieves rapid deposition of polycrystalline diamond. Its deposition rate is significantly higher than other CVD techniques, but the grain size is larger and the internal stress is higher.

Electrochemical advanced oxidation processes

Electrochemical advanced oxidation processes is an efficient and environmentally friendly organic wastewater treatment method. In the electrochemical oxidation process, organic matter is oxidized into carbon dioxide and water, which will not produce secondary pollution and the degradation rate of organic matter is very high.
This technology uses electrode materials with catalytic activity to directly or indirectly produce hydroxyl free radicals during the electrode reaction process to achieve the purpose of decomposing and degrading organic pollutants.

Boron-Doped Diamond (BDD) Electrode

The unique sp^3 bond structure of diamond and its conductivity after doping with boron endow BDD electrodes with excellent electrochemical properties. BDD electrode is an excellent material choice for electrochemical oxidation process.
The electrochemical oxidation of organic matter occurs at the electrode or liquid interface. The choice of anode material directly influences the efficiency and selectivity of the mineralization process for organic matter, Therefore, the development of economically viable and efficient anode materials for the degradation of organic wastewater has long been a focal point of research in the field of electrochemical oxidation.



Boron-doped diamond electrode has a relatively high oxygen evolution potential and a relatively wide electrochemical window, and is an ideal anode material for electrochemical oxidation treatment of difficult-to-biodegrade organic wastewater.

Advantages of BDD electrodes

01 High oxygen evolution potential and strong oxidation ability

The electrode reaction produces enhanced hydroxyl radicals, which can effectively degrade organic pollutants;

02 Without secondary pollution

The adsorption capacity is weak, and pollutants will not accumulate on the electrode surface; No external reagents are required during the process, which can avoid secondary pollution;

03 Stable electrochemical performance and corrosion resistance

BDD electrodes can still maintain good stability and electrode activity under acidic, neutral and alkaline conditions;

04 No consumption of electrodes, long service life

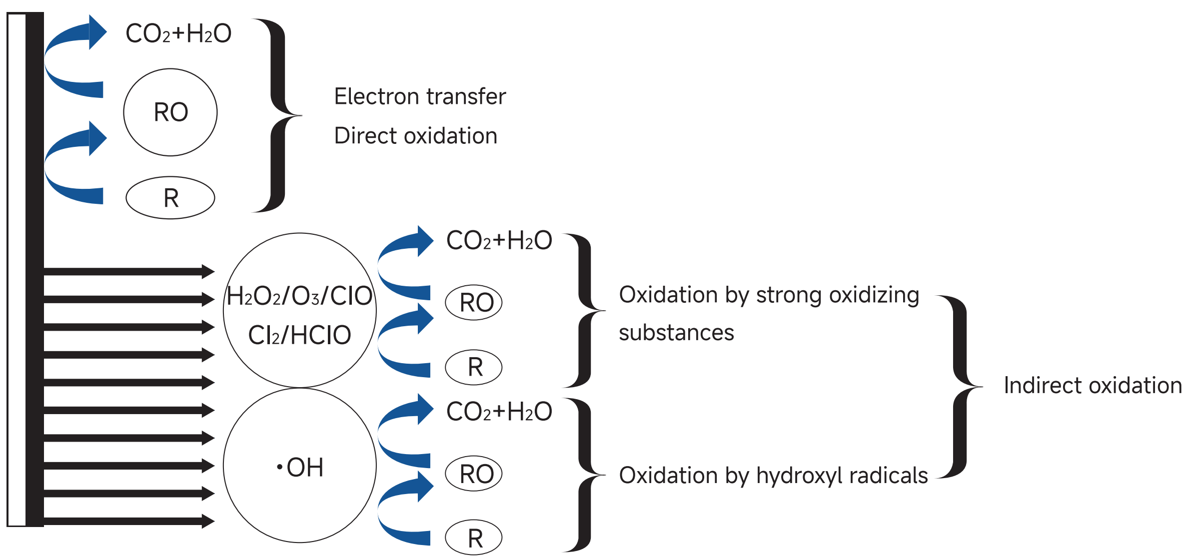
Compared with consumable electrodes such as ruthenium, iridium, titanium, and graphite, BDD electrodes have the characteristics of high diamond hardness, strong wear resistance, chemical inertness, and resistance to strong acids and alkalis.

Technical principles and core mechanisms of BDD electrochemical oxidation

There are two forms of oxidation when BDD electrode is used for anode electrochemical oxidation:

→ 1.Direct oxidation: The oxidative removal of organic matter is realized through the adsorption of organic pollutants on the anode surface in the form of electron transfer, and the organic matter can be directly converted into CO_2 and H_2O.

→ 2.Indirect oxidation: Oxidative removal of organic matter through the generation of hydroxyl radical on the anode surface.



Characteristics of hydroxyl radical(·OH)①

01 Higher redox potential

The oxidation electrode potential of hydroxyl radical is notably higher than that of some other commonly used strong oxidizing agents, ranking second only to fluorine.

02 Fast rate of chemical reaction

Hydroxyl radical exhibit high reactivity, and the chemical reactions they engage in are classified as free radical reactions, characterized by their rapid reactions.

03 High electronegativity

The electron affinity energy of hydroxyl radical is measured at 569.3kJ②, and this electrophilic capability governs the selective reactivity of hydroxyl radical towards specific target pollutants.

04 Without secondary pollution

Ultimately, the pollutants undergo complete oxidation, resulting in the formation of carbon dioxide (CO_2)and water (H_2O),thereby achieving environmentally friendly and efficient treatment, meeting emission standards.

①Note: Content source: The above discussion and data source on "Characteristics of Hydroxyl Radicals (·OH)" can be found in the article "Characteristics of Hydroxyl Radicals and Their Chemical Reactions", Journal of Dalian Maritime University, No. 1006-736 (2004) 03.0062-03, for reference only

②Note: Content source: The above discussion and data source on "The electron affinity energy of hydroxyl radical is measured at 569.3kJ " can be found in "Advances in Environmental Protection" 2022, 12(1), 44-50, for reference only.

Sulfate radical (SO_4^-·) characteristics

→ Its redox potential (2.6~3.10V) is close to ·OH (2.8V);

→ The half-life (4S) is much higher than ·OH (10^{-4}S), which can degrade organic matter more efficiently;

→ SO_4^-· can produce other free radicals such as hydroxyl (·OH) and superoxide radical (·O_2^-) through chain reactions.

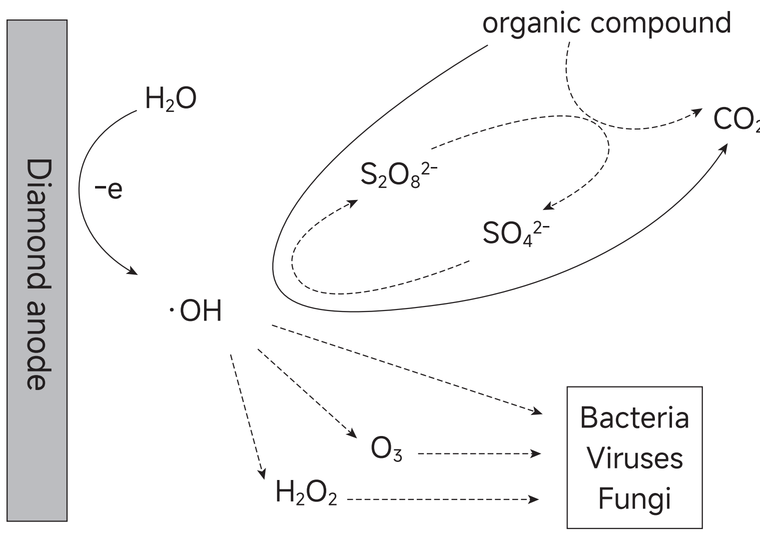
*There are two commonly used persulfates in the process, namely peroxymonosulfate (PMS) and peroxydisulfate (PMD).

Schematic diagram of electrochemical oxidation technology

→ Diamond film electrodes generate highly oxidizing · OH through electrolysis of water, which can oxidize organic matter to produce water, CO_2, and corresponding inorganic substances;

→ ·OH oxidizes sulfate ions (SO_4^{2-}) to generate persulfate ions ($S_2O_8^{2-}$), which can further enhance the oxidation effect;

→ ·OH and its reaction in water produce O_3 and H_2O_2.



Introduction to BDD electrochemical oxidation process

→ Pretreatment:

Degrade toxic substances in raw wastewater, produce ring-opening and chain-breaking reactions, and improve the biodegradation of wastewater.

→ Tailwater upgrading and transformation:

Suitable for large amounts of wastewater. It is difficult to degrade COD to around 50mg/L using conventional Fenton and ozone advanced oxidation methods.

→ Full-process treatment:

Suitable for small amounts of wastewater with high concentration, can meet the discharge standards after electrolytic process.

→ Pre-evaporation treatment:

Before evaporation, degrading the COD of wastewater can improve evaporation efficiency, enhance the purity of salt, reduce the entry of evaporation bubbles into the fan pipeline, and prevent equipment damage.

→ Membrane concentrated mother liquor:

Small amounts of wastewater can be directly discharged by electrolytic process, large amounts of wastewater need to reduced before recirculation treatment.

→ Evaporative concentrate liquid:

The concentrated mother liquor, which is high in salt and COD, is typically recycled back to the front end for reuse. However, when it reaches a certain level, it becomes unable to evaporate and can only be disposed of as hazardous waste.The evaporated concentrated solution can be degraded with BDD and continuously recycled for reuse.

Application of BDD electrodes

High-risk, high-toxicity, high-salt, high-ammonia nitrogen, high-chroma, strong acid and strong alkali organic wastewater, such as production wastewater from fine chemical, pharmaceutical, pesticide, petrochemical, coking, lithium battery, leather making, electroplating, brewing and other industries.

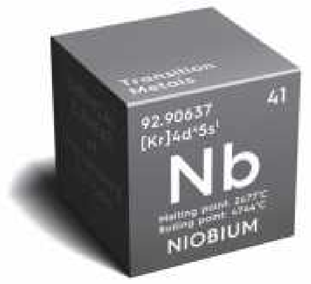
Required properties of BDD matrix

Small thermal expansion coefficient;
Good electrical conductivity;

Good chemical stability of itself and carbides;
High resistance to hydrogen embrittlement;

No phase change within the deposition temperature range;

Not too expensive (economical).



Advantages of niobium based materials

→ **Power saving:** low resistance, low power consumption, can significantly reduce the operating costs of equipment.
→ **Corrosion resistance:** high chemical stability, strong acid and alkali resistance.
→ **Easy to connect:** low contact resistance, which is beneficial for simplifying the electrolytic cell.
→ **Not easy to break:** high strength, not easy to break during use, and easy to transport.
→ **Improving mass transfer:** easy to form various shapes such as mesh and wave, which is beneficial for improving the mass transfer process.
→ **Space saving:** thin plates can be used to reduce costs and increase the available space of the electrolytic cell.

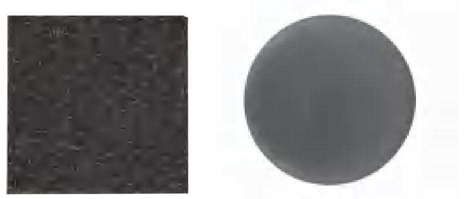
Integrated equipment (customized)

Product Introduction

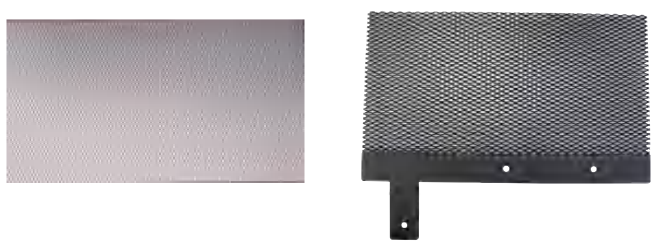
Niobium-based/Silicon-based BDD electrodes

Worldia BDD electrodes production equipment can not only make BDD coating on large-area niobium mesh, but also on non-metallic surfaces, and can produce large-size full-surface CVD diamond film coated electrodes with substrate sizes up to 700mm*500mm.
Customized products can be provided according to customer requirements, which can achieve import substitution of similar products and help customers reduce costs and increase efficiency.

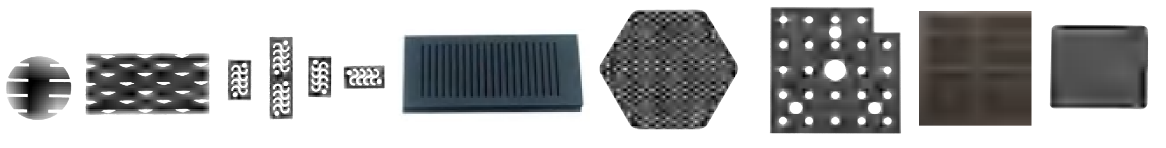
Niobium-based/Silicon-based BDD electrodes



BDD thick film material



Niobium mesh electrodes



Niobium-based/Silicon-based BDD ozone electrodes

Worldia BDD electrode technical index parameters

Strictly follow the relevant requirements of ISO9001 and ISO14001 management system for production and quality management.

Niobium-based BDD SEM image


SEM5000x

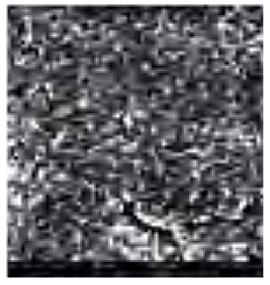

SEM7000x

Niobium-based BDD SEM image


SEM8000x

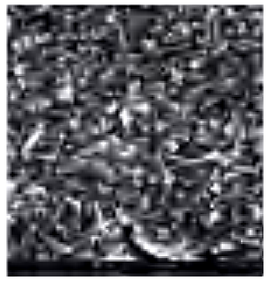

SEM9000x

Silicon-based BDD SEM image


SEM6000x


SEM7000x

Silicon-based BDD SEM image


SEM8000x


SEM9000x

Specification and application requirements of niobium-based BDD electrode

Ltem	Size(mm)	Oxygen precipitation potential(V)	Hydrogenation potential(V)	Resistivity(Ω.cm)	Diamond film thickness(um)
Performance	L*W*T 240*130*1	≥2.8	<-1.0	≤0.00002	10±2

Ltem		Operating requirements
Package		PP/Stainless steel lined with PTFE package
Current density(mA/cm²)		<50
Water quality	PH	2~13
	TDS(g/L)	>4,<70% saturation
	Fluoride	No specific requirements
	Total hardness(mg/L)	<300
	Suspended solids(mg/L)	<80
	Water temperature(°C)	<60

Specification and application requirements of silicon-based BDD electrode

Ltem	Size(mm)	Oxygen precipitation potential(V)	Hydrogenation potential(V)	Resistivity(Ω.cm)	Diamond film thickness(um)
Performance	L*W*T 240*130*3	≥2.8	< -1.0	≤0.02	10±2

Ltem		Operating requirements
Package		PP/Stainless steel lined with PTFE package
Current density(mA/cm²)		<50
Water quality	PH	2~13
	TDS(g/L)	>4,<70% saturation
	Fluoride(mg/L)	<20
	Total hardness(mg/L)	<300
	Suspended solids(mg/L)	<80
	Water temperature(°C)	<60

*Specifications and dimensions of Niobium/Silicon-based BDD electrodes can be customized

Maximum size: 700*500mm

BDD electrolytic reactor

→ Compact size and easily transportable; features standard inlet and outlet interfaces for convenient installation;

→ Configurable for series or parallel connection, making it ideal for large-scale wastewater treatment projects;

→ Integration of anodes, cathodes, and the bus bar is accomplished through specialized techniques;

→ Equipped with a dedicated power supply that automatically switches between anodes and cathodes at specified intervals;

→ PP/Stainless steel lined with PTFE package

Acrylic package pilot test module

PP package engineering module of Niobium/Silicon-based BDD

Parameters of BDD electrolytic reactor

Product parameter 1			
External dimension(mm)	440*310*200	Current(A(Max))	400
Water inlet	1-inch internal thread interface	Operating power(kW)	Less than 6
Water outlet	1.2-inch internal thread interface	Processing capacity(kg(COD)/h)	0.5
Anode	12 pieces of 240*130*1mm Niobium-based BDD	Circulation flow(m^3/h)	4
Cathode	13 pieces of Titanium plate	Weight(kg)	Approx. 17

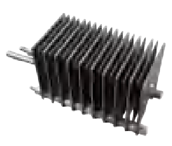
Product parameter 2			
External dimension(mm)	440*310*200	Current(A(Max))	400
Water inlet	1-inch internal thread interface	Operating power(kW)	Less than 6
Water outlet	1.2-inch internal thread interface	Processing capacity(kg(COD)/h)	0.5
Electrode	12 pieces + 13 pieces of 240*130*1mm Niobium-based BDD Cathode and cathode can be switched	Circulation flow(m^3/h)	4
		Weight(kg)	Approx. 18.7

BDD experimental equipment for wastewater treatment

→ To meet the demand for end customers to use it immediately

→ Used for various small-scale experiments

→ Suitable for preliminary testing, simulating wastewater treatment effects, and simultaneously accumulating data for engineering applications



Before package

After package

Technical specifications and usage requirements of BDD wastewater treatment experimental equipment

Electrode	Quantity (pcs)	Specification (mm)	Anode-cathode spacing(mm)	Diamond effective use area(cm^2)	Size(mm)	oxygen evolution potential (v)	Hydrogen evolution potential(v)	Resistivity (Ω.cm)
BDD anode	9	28*28*1	1.5~2	140	L*W*H 200*60*50	≥2.8	<-1.0	≤ 0.00002
Titanium -cathode	10	28*28*1						
Wiring	The red wire connects to the anode, for positive pole of the power supply, while the blue wire connects to the cathode, for negative pole of the power supply.							

Item		Operating requirements
Current density(mA/cm^2)		≤50
Water quality	PH	2~13
	TDS(g/L)	>4,<70% saturation
	Total hardness(mg/L)	<300
	Suspended solids(mg/L)	<80
	Water temperature(°C)	<60

BDD beaker experimental equipment for wastewater treatment

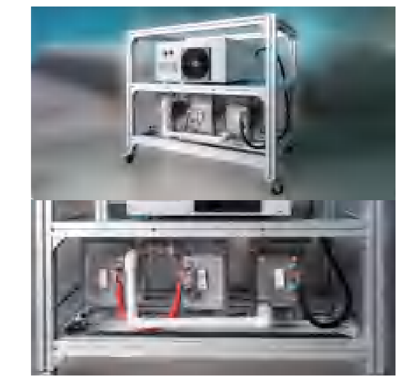
Technical specifications and Parameters									
Beaker capacity (ml)	Electrode Materials	Polarity switchable	Specifications L*W*T(mm)	Number of electrodes (pcs) Anode + cathode	Diamond effective use area (cm^2)	Oxygen evolution potential (V)	Hydrogen evolution potential (V)	Resistivity (Ω·m)	Current density (mA/cm^2)
1500	Niobium-based BDD	YES	120*65*1	20	3120	≥2.8	<-1.0	<0.01	50
1500	Niobium-based BDD	YES	120*65*1	8	1248				
300	Niobium-based BDD	YES	28*28*1	9+10	290				
300	Niobium-based BDD +titanium plate	NO	28*28*1	9+10	140				
1500	Silicon-based BDD +titanium plate	NO	120*65*3 Silicon-based BDD	2	312				
			130*75*3 Titanium plate	3					
Note:Power supply + water pump + hose + aluminum alloy suitcase									

Operating requirements		
Current density(mA/cm^2)		<50
Water quality	PH	2~13
	TDS(g/L)	>4,<70% saturation
	Total hardness(mg/L)	<300
	Suspended solids(mg/L)	<80
	Water temperature(°C)	<60

BDD-MT12 series engineering module

Worldia BDD-MT12 series engineering module is an integrated advanced oxidation wastewater treatment device that uses electrochemical oxidation to treat high-salt, high-toxicity, high-concentration, strong acid and alkali, and difficult-to-degrade industrial organic wastewater, and efficiently degrades COD and removes ammonia nitrogen.

It can provide full-process R&D support from pilot to engineering application for the treatment of high-difficulty wastewater, and realize the industrial application of large-size and large-area BDD electrodes.



Advantages of BDD-MT12 series engineering modules

→ Wide treatment range:
Applicable to "high salt, high ammonia nitrogen, high COD, high toxicity, difficult to degrade" industrial wastewater.

→ Flexible application:
1. Single treatment process: ① Full-process treatment; ② Advanced treatment
2. Coupling other processes: ① Biological oxidation; ② Ozone oxidation; ③ Evaporation; ④ Membrane concentration

→ No need for external agents, no secondary pollution: "Electronics" as a cleaning agent, no selective oxidation, no sludge production.

→ Modular design, good scalability, small occupation.

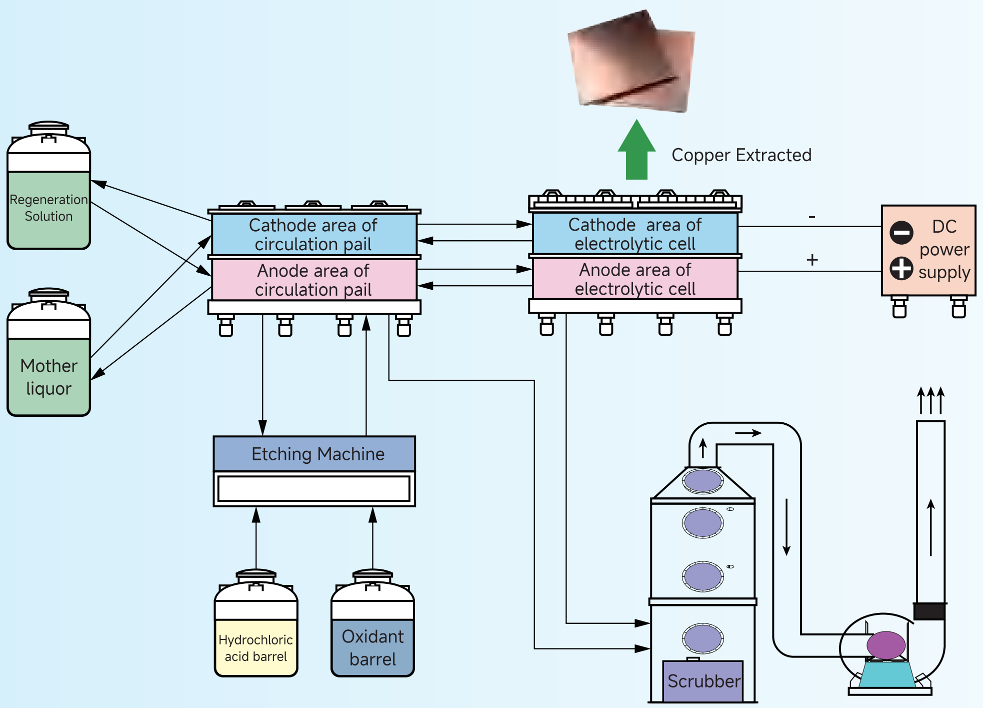
→ Simple operation and maintenance.

Parameters of BDD-MT12 series engineering module	
Size-length*width*height (mm)	1200*700*900
Total weight (KG)	215
Composition	Three sets of niobium/silicon-based BDD reactors
Contains in each reactor	12 pieces of niobium-based BDD anodes+13 pieces of titanium cathode plates
Single electrode size (mm)	240*130*1
BDD anode area of each reactor(m^2)	0.75
BDD area of the whole equipment(m^2)	2.25
Voltage (V)	30
Current (A (Max))	400
Power (kw)	12
Circulation flow of a single device (t/h)	12

Application Cases

PCB micro-etching liquid recycling regeneration& copper extracted

Ion-exchange membrane electrolyzer technology



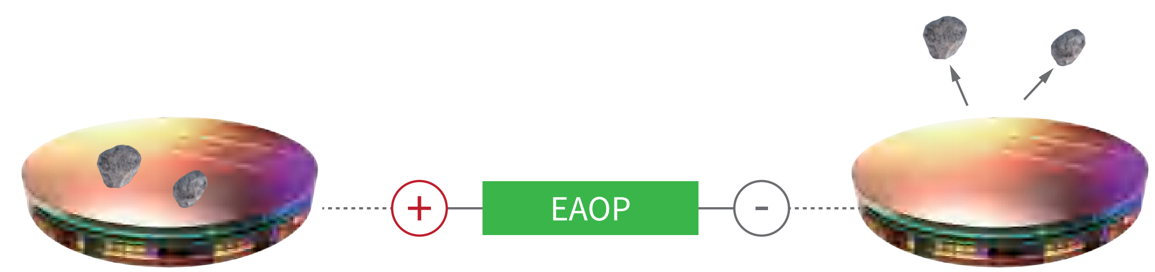
Micro-etching waste liquid is recycled without secondary pollution
Recycling and regeneration of copper, process flow chart for producing sodium persulfate

The micro-etching waste liquid adopts sulfuric acid-sodium persulfate system. During the process of micro etching copper, the waste liquid undergoes a reaction of $Na_2S_2O_8$ + Cu =Na_2SO_4 + $CuSO_4$. When the concentration of sodium persulfate in the micro-etching solution decreases and the copper ion increases, the micro-etching ability of the micro-etching solution decreases. After becoming micro-etching waste liquid, the micro-etching waste liquid needs to be replaced or regenerated. The micro-etching solution is regenerated by ion membrane electrolysis process. The anode is an oxygen-evolving high-potential anode, and the cathode is a stainless steel plate or a titanium plate. An ion membrane separates the anode solution from the cathode solution, where the cathode is the micro-etching waste liquid, and the anode is the micro-etching waste liquid that needs to be regenerated. That is, while the micro-etching solution is regenerated at the anode, copper can also be recovered by electroplating at the cathode, so that the copper added during the micro-etching process can be recovered. The high-copper micro-etching waste liquid on the production line enters the waste liquid collection bucket, and then enters the cathode area of the electrolytic cell to electrolytically deposit copper to obtain low-copper regeneration liquid. The low-copper regeneration liquid is temporarily stored in the regeneration liquid bucket, and then enters the anode area of the electrolytic cell to oxidize the sodium sulfate in the regeneration liquid into sodium peroxyacid, and after restoring the micro-etching ability of the micro-etching liquid, it becomes a low-copper liquid, and the low-copper liquid returns to the micro-etching tank to continue micro-etching copper.

Cleaning process for semiconductor industry

Contaminants on the wafer, especially metal particles, can cause significant damage to the wafer. These metal particles often adhere to the wafer through electrostatic adsorption and are almost impossible to remove. The smaller the particles, the more difficult it is to remove them.

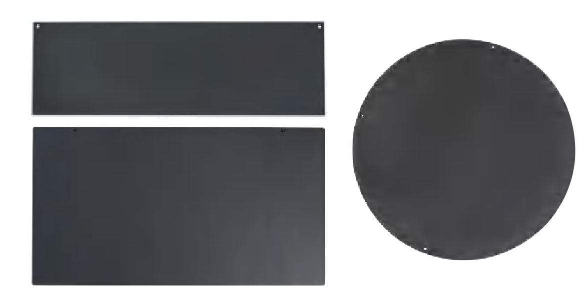
In the semiconductor industry, BDD electrodes can be used for cleaning wafers and devices, as well as for oxidation protection of metal based microstructures. Reducing costs and improving process stability are the main goals of large-scale production in the semiconductor industry. In the oxidation cleaning tank, traditionally a mixed solution of sulfuric acid and hydrogen peroxide is used for wet cleaning. The new process, BDD electrode produces persulfate by electrolyzing sulfuric acid, which can effectively remove photoresist and significantly reduce the amount of chemical liquid used compared to traditional methods.



Industrial wastewater treatment

Pharmaceutical, pesticide, chemical, petrochemical, coking, smelting, printing and dyeing, papermaking, leather, lithium battery wastewater.

Mesh Niobium-based BDD electrode



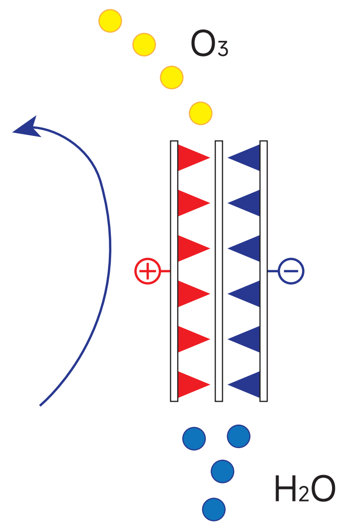
Niobium/Silicon-based BDD electrode

Improving the shortcomings of conventional ozone generators

Electrolysis for ozone production

By employing low-voltage direct current, water undergoes electrolysis to initiate an oxidation reaction at the anode-solution interface, leading to the production of ozone.

The apparatus incorporates an exceptionally thin layer of sodium ion exchange membrane positioned between the anode and cathode. Upon the application of electric current, an exceptionally high concentration of radicals is promptly generated. However, these radical species exhibit high instability in contrast to their reactions with organic compounds during the treatment of organic wastewater. Instead, they can only undergo transformation into the more stable ozone. Consequently, ozone water is obtained.



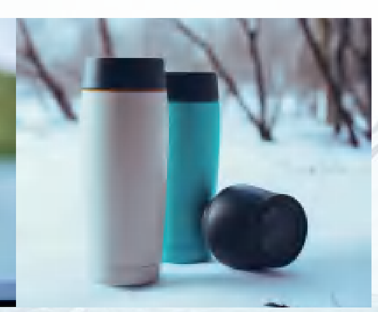
Comparison with conventional ozone generators

Item	Electrolysis	Conventioanl high-frequency and high-voltage corona discharge
Raw Material	Pure water/ Tap water	Air or pure oxygen
Treatment process	Simple process	The complex process requires pre-treatments such as freezing, dehumidification, drying, and adsorption
Working pressure	Depending on applications, atmospheric pressure can be adjusted from 0-10kg/cm²	The raw gas must be pressurized and dissipate heat through the discharge chamber; otherwise, it may damage electrical components
Ozone purity	Generate O_2 and O_3, without secondary pollution	Generate nitrogen oxides
Ozone gas concentration	25-30%, high solubility in water	3-12%, low solubility in water
Ozone water concentration	0-50mg/L	0-10mg/L
Power supply	Low-voltage direct current (single-cell voltage: 3V to 4V)simple and safe circuit; Can work in humid environment	High-frequency, high-voltage alternating current (several thousand to tens of thousands of volts) with a complex and poor safety circuit
Secondary pollution	No nitrogen oxides, noise, radiation	Noise, electromagnetic radiation, nitrogen oxides

BDD ozone water generator efficiently solves conventional problems through low-pressure electrolysis of water

It can be applied to products such as fruit and vegetable washing machines, portable disinfection devices, disinfectant towel dispensers, and disinfectant mouthwash cups.





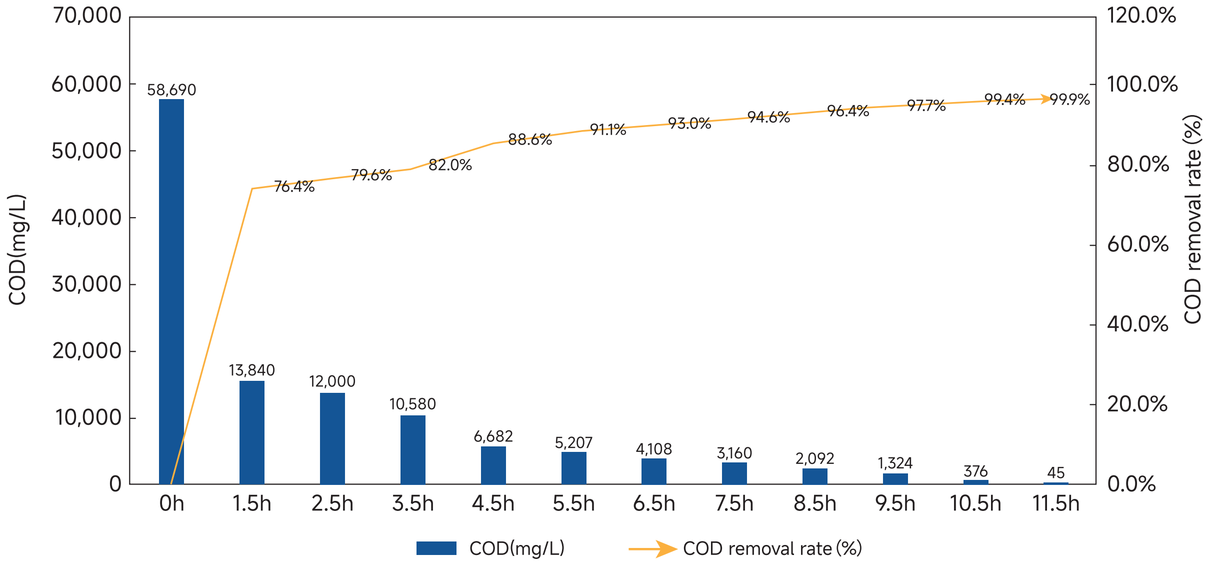
WORLDIA BDD ELECTRODES

Quick view of application cases

Data source: Experimental reports from BDD Project Department of Beijing Worldia Diamond Tools Co., Ltd.

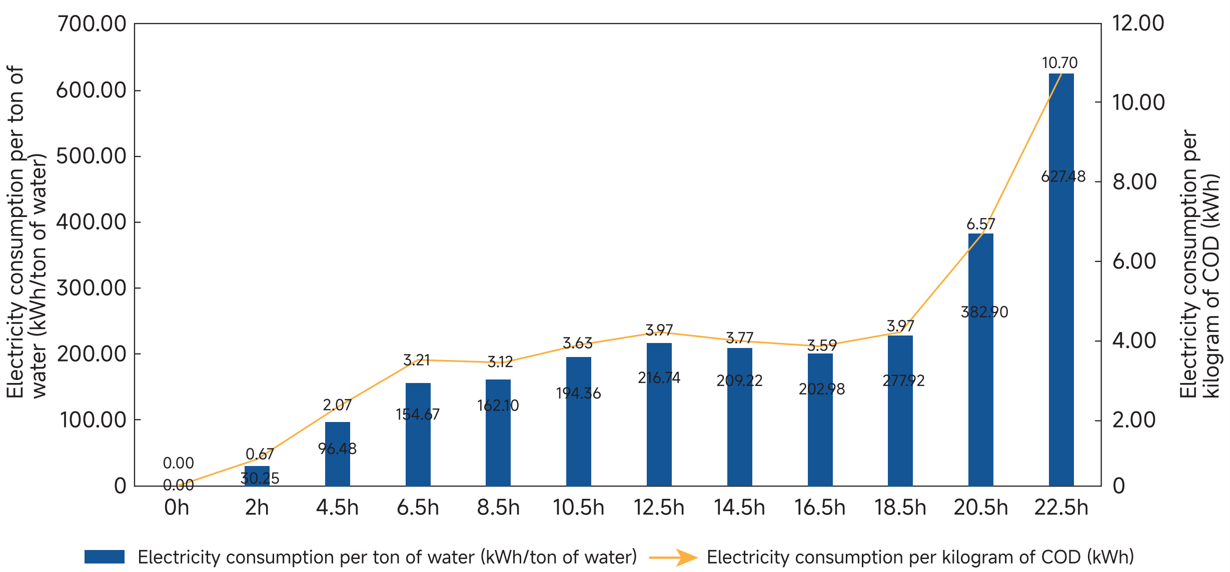
Wastewater from photoresist material production

Experimental result about COD removal rate of 50L pilot module



	0h	1.5h	2.5h	3.5h	4.5h	5.5h	6.5h	7.5h	8.5h	9.5h	10.5h	11.5h
COD(mg/L)	58,690	13,840	12,000	10,580	6,682	5,207	4,108	3,160	2,092	1,324	376	45
COD removal rate(%)	0.0%	76.4%	79.6%	82.0%	88.6%	91.1%	93.0%	94.6%	96.4%	97.7%	99.4%	99.9%

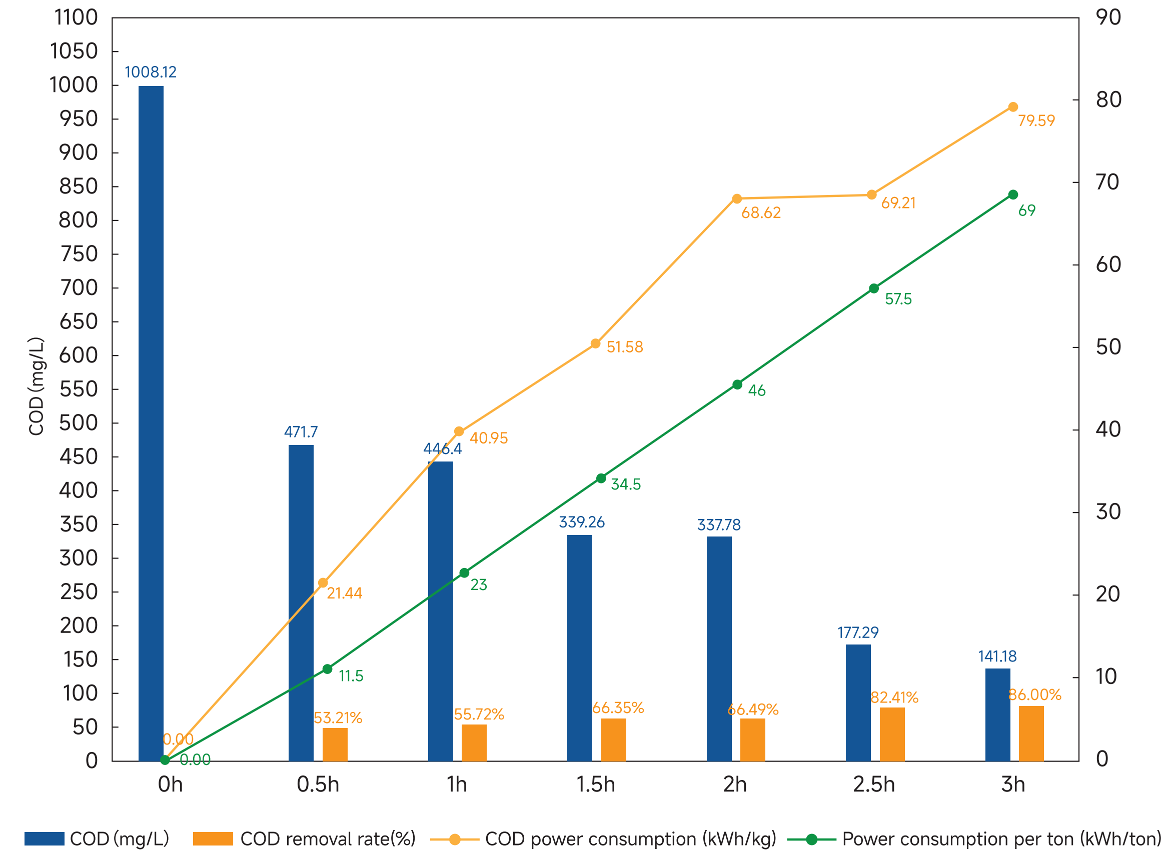
Experimental result about power consumption per ton of water of 50L pilot module



	0h	2h	4.5h	6.5h	8.5h	10.5h	12.5h	14.5h	16.5h	18.5h	20.5h	22.5h
Electricity consumption per ton of water (kWh/ton of water)	-	30.25	96.48	154.67	162.10	194.36	216.74	209.22	202.98	227.92	382.90	627.48
Electricity consumption per kilogram of COD (kWh)	-	0.67	2.07	3.21	3.12	3.63	3.97	3.77	3.59	3.97	6.57	10.70

High-salt wastewater from wet method smelting in cobalt factory

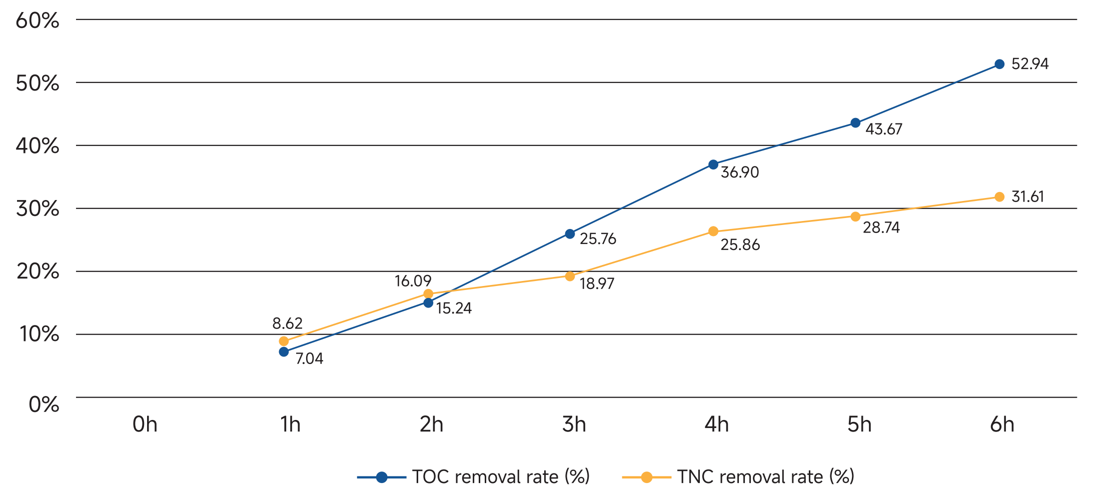
Pilot test data of high-salt wastewater from wet method smelting in cobalt factory



	0h	0.5h	1h	1.5h	2h	2.5h	3h
COD(mg/L)	1008.12	471.7	446.4	399.26	337.78	177.29	141.18
COD removal rate(%)	0.00	53.21	55.72	66.35	66.49	82.41	86.00
COD power consumption (kWh/kg)	0	21.44	40.95	51.58	68.62	69.21	79.59
Power consumption per ton (kWh/ton)	0	11.5	23	34.5	46	57.5	69

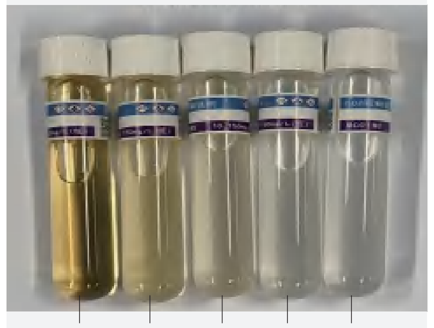
Analytical data of TOC and total nitrogen removal effects of Industry hypersaline wastewater and electro-oxidation for 1-6 hours

The removal effect of TOC and total nitrogen by Industry hypersaline wastewater and electro-oxidation for 1-6 hours



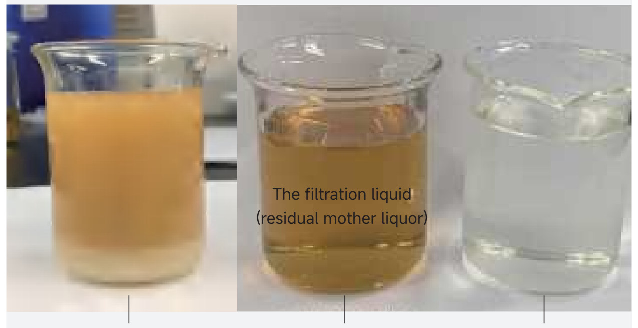
	Raw water	Electro-oxidation 1h	Electro-oxidation 2h	Electro-oxidation 3h	Electro-oxidation 4h	Electro-oxidation 5h	Electro-oxidation 6h
TOC removal rate (%)	-	7.04	15.24	25.76	36.90	43.67	52.94
TNC removal rate (%)	-	8.62	16.09	18.97	25.86	28.74	31.61

Color comparison of Industry hypersaline wastewater and electro-oxidation 1-4 hours later



Raw water 1h 2h 3h 4h

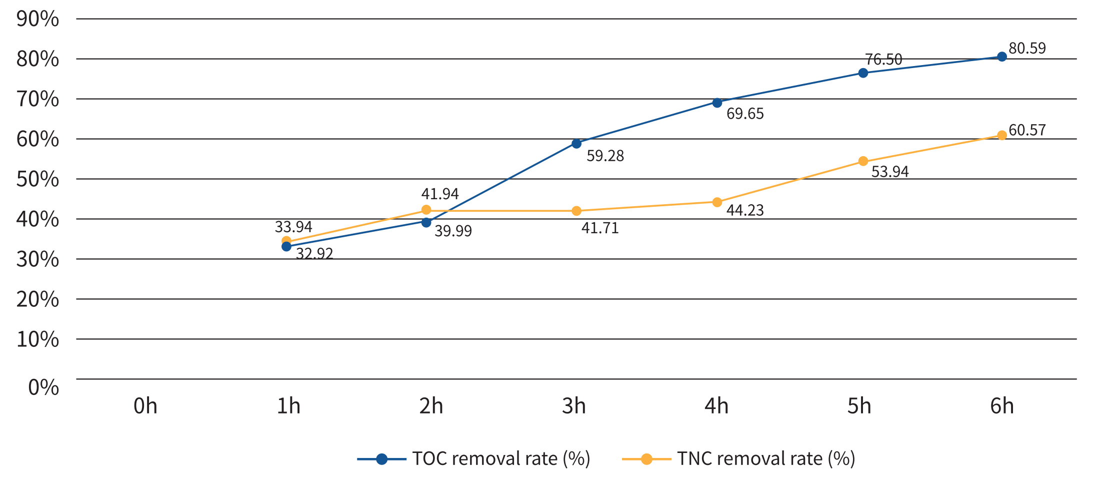
Color comparison of waste salt raw water and electro-oxidation 6 hours later



Mother liquor | Raw water before electro-oxidation | Effluent water after 6hours of electro-oxidation

Analytical data of TOC and total nitrogen removal effects of Evaporative crystallization mother liquor and electro-oxidation for 1-6 hours

The removal effect of TOC and total nitrogen by Evaporative crystallization mother liquor and electro-oxidation for 1-6 hours



	Raw water	Electro-oxidation 1h	Electro-oxidation 2h	Electro-oxidation 3h	Electro-oxidation 4h	Electro-oxidation 5h	Electro-oxidation 6h
TOC removal rate (%)	-	32.92	39.99	59.28	69.65	76.50	80.59
TNC removal rate (%)	-	33.94	41.94	41.71	44.23	53.94	60.57

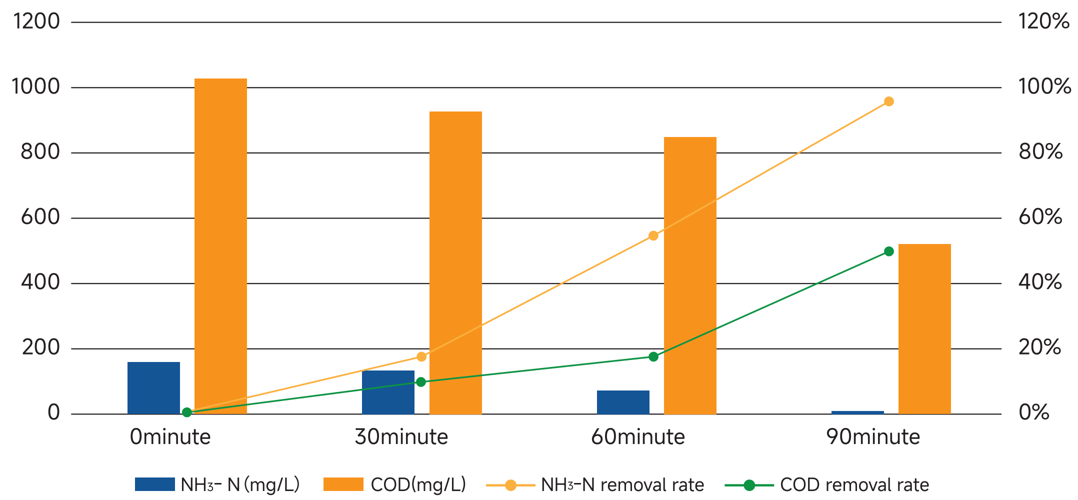
Color comparison of Evaporative crystallization mother liquor and electro-oxidation 1-6 hours later

Raw water 1h 2h 3h 4h 5h 6h

Color comparison of Evaporative crystallization mother liquor and electro-oxidation 6 hours later

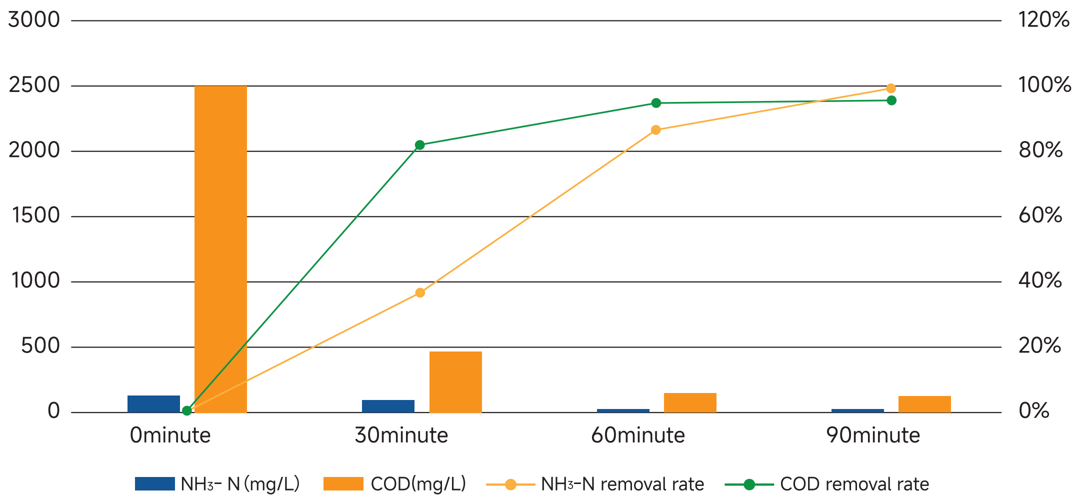
Raw water before electro-oxidation | Effluent water after 6 hours of electro-oxidation

Experimental data of nanofiltration concentrate from coal chemical industry



	0minute	30minute	60minute	90minute
NH_3- N (mg/L)	159.00	131.00	72.10	7.01
COD(mg/L)	1,029.00	932.00	852.00	520
NH_3-N removal rate	0.00%	17.61%	54.65%	95.55%
COD removal rate	0.00%	9.43%	17.20%	49.47%

Experimental data of multi-media raw water from coal chemical industry



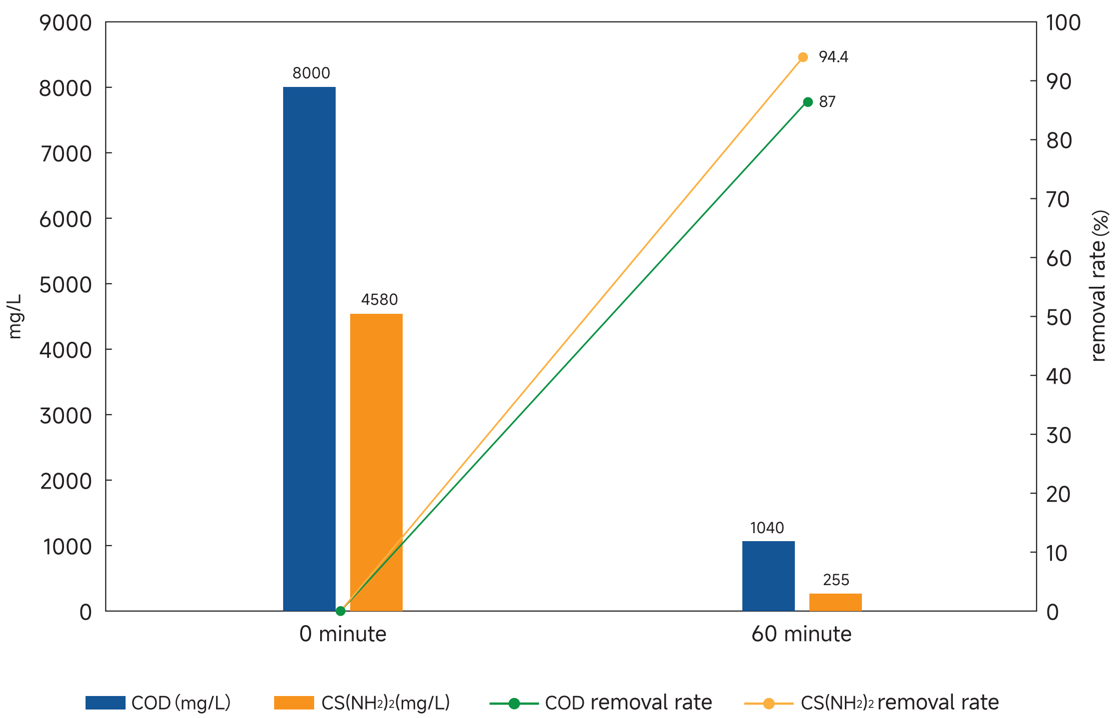
	0minute	30minute	60minute	90minute
NH_3- N (mg/L)	120.00	76.20	16.30	0.74
COD(mg/L)	2,494.00	459.00	140.00	115
NH_3-N removal rate	0.00%	36.50%	86.42%	99.38%
COD removal rate	0.00%	81.60%	94.39%	95.39%

Small-scale experimental results of thiourea wastewater

Raw water COD (mg/L)	Raw water $CS(NH_2)_2$ (mg/L)	Effluent COD (mg/L)	Effluent $CS(NH_2)_2$ (mg/L)	COD removal rate (%)	$CS(NH_2)_2$ removal rate (%)	Energy consumption (kWh/m³)
8000	4580	1040	255.0	87.0	94.4	1.1

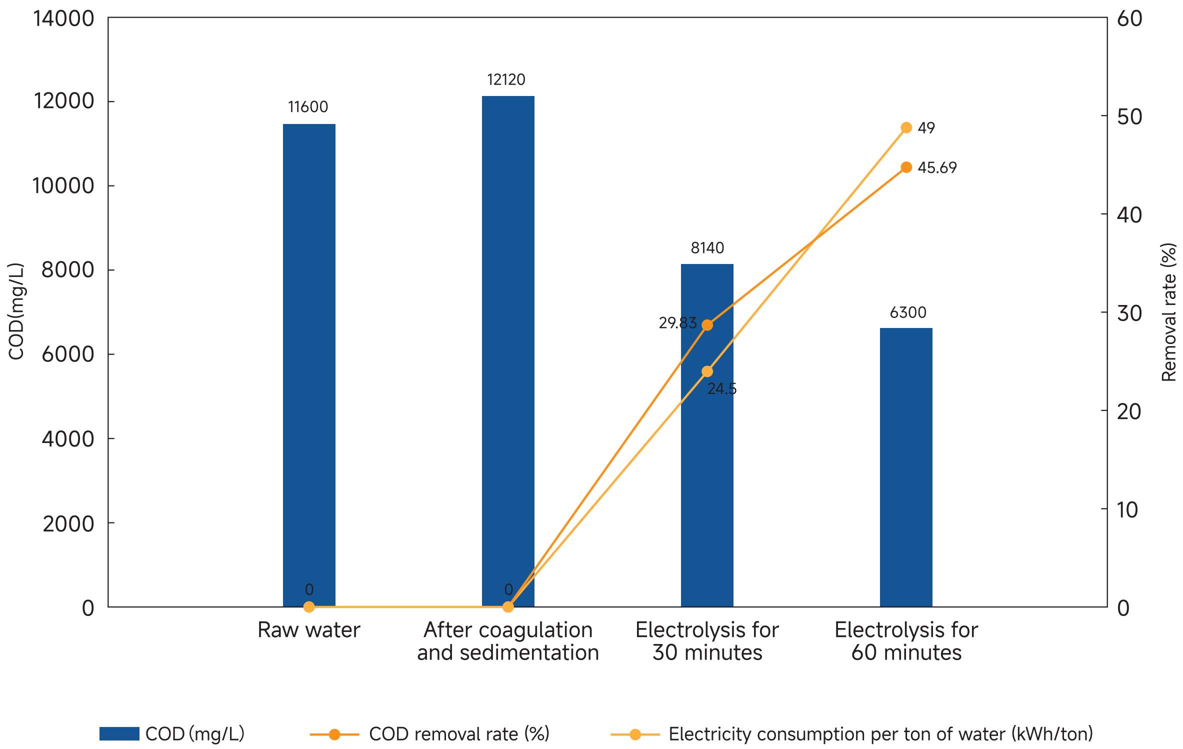
Worldia BDD small-scale experimental module: after 1 hour, the thiourea removal rate reached 94.4% and the COD removal rate reached 87%.

Results of one-hour experimental study on the treatment of thiourea wastewater by BDD small-scale experimental module



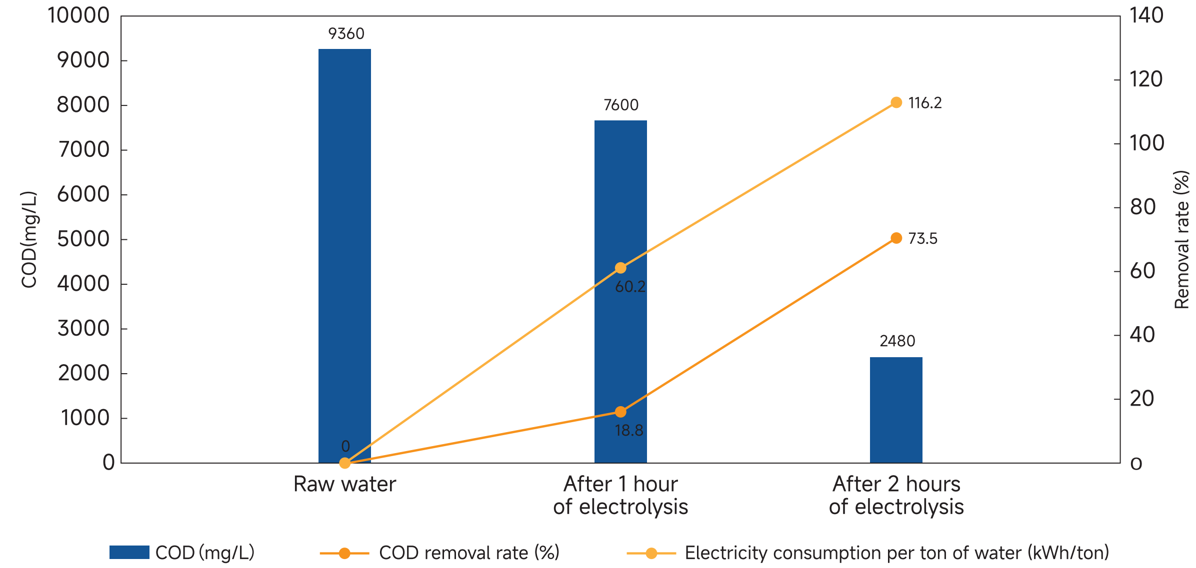
	0 minute	60 minute
COD (mg/L)	8000	1040
$CS(NH_2)_2$(mg/L)	4580	255
COD removal rate	0%	87%
$CS(NH_2)_2$ removal rate	0%	94.4%

Experimental data of treating 1L of garlic washing water for 1 hour using niobium-based BDD beaker wastewater treatment

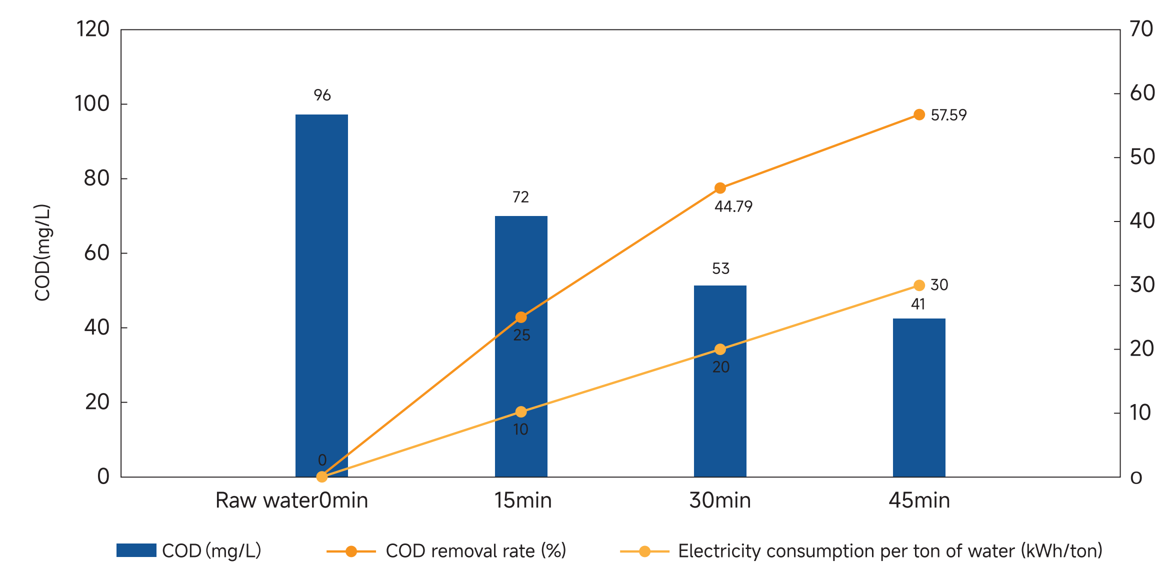


	Raw water	After coagulation and sedimentation	Electrolysis for 30 minutes	Electrolysis for 60 minutes
COD(mg/L)	11600	12120	8140	6300
COD removal rate (%)	0	0	29.83	45.69
Electricity consumption per ton of water (kWh/ton)	0	0	24.5	49

Experimental data of treating special material production wastewater using niobium-based BDD beaker wastewater treatment

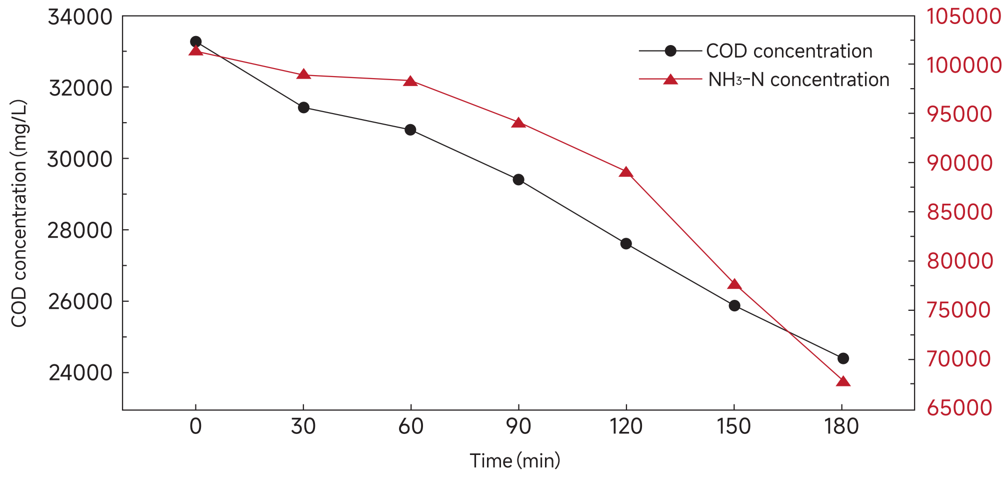


	Raw water (special material production wastewater A)	After 1 hour of electrolysis	After 2 hours of electrolysis
COD(mg/L)	9360	7600	2480
COD removal rate (%)	0	18.8	73.5
Electricity consumption per ton of water (kWh/ton)	0	60.2	116.2

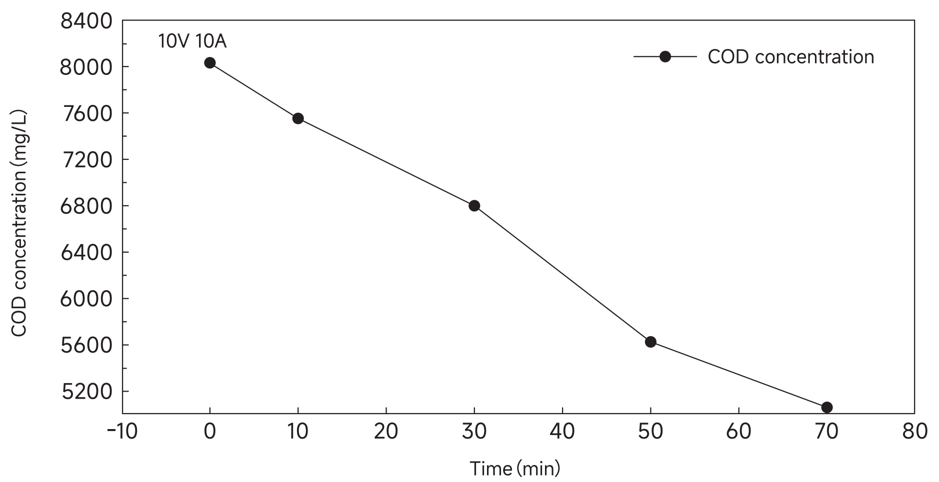


	Raw water (special material production wastewater B)	15min	30min	45min
COD(mg/L)	96	72	53	41
COD removal rate (%)	0	25	44.79	57.59
Electricity consumption per ton of water (kWh/ton)	0	10	20	30

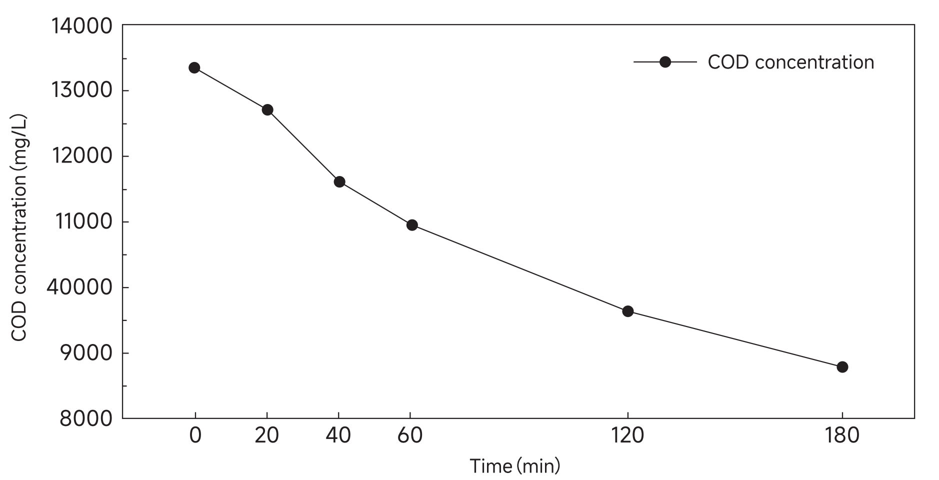
Membrane pretreated concentrate of petrochemical wastewater



Petrochemical wastewater



Aramid wastewater



A wastewater treatment facility in a chemical park in Ningbo, Zhejiang Province, was designed to produce effluent with a COD of less than 40mg/L. However, the long-term actual operation showed a COD exceeding 60mg/L, failing to meet the design effluent standards. After on-site pilot testing, the effluent consistently meets the 40mg/L standard.

Date	Flow m^3/h	Effective HRT S	Current A	Voltage V	Output Power kw	Inlet Conductivity ms/cm	Inlet COD mg/L	Produce 1 COD of water	Net COD Removal	gCOD/ h	gCOD/ m^2/	gCOD/ (KW)	kwh/ gCOD	Power Consumption
12.6	5.90	3.66	700	7.16	5.33	11.39	62.00	44.40	17.60	103.84	52.44	19.49	0.051	0.90
	5.90	3.66	800	7.95	6.36	11.26	62.00	43.70	18.30	107.97	54.53	16.98	0.059	1.08
	5.90	3.66	900	8.29	7.46	11.32	62.00	43.20	18.80	110.92	56.02	14.87	0.067	1.26
	5.90	3.66	1000	8.66	8.66	11.22	62.00	42.70	19.30	113.87	57.51	13.15	0.076	1.47
	5.90	3.66	1100	9.03	9.93	11.31	62.00	41.60	20.40	120.36	60.79	12.12	0.083	1.68
	5.90	3.66	1200	9.39	11.27	11.31	62.00	39.90	22.10	130.39	65.85	11.57	0.086	1.91
	5.90	3.66	1300	9.75	12.68	11.4	62.00	39.40	22.60	133.34	67.34	10.52	0.095	2.15
	5.90	3.66	1400	10.1	14.14	11.25	62.00	36.20	25.80	152.22	76.88	10.77	0.093	2.40

From the above data, it clearly indicates that as the current increases, power consumption and COD removal rate also increase.

Date	Flow m^3/h	Effective HRT S	Current A	Voltage V	Output Power kw	Inlet Conductivity ms/cm	Inlet COD mg/L	Produce 1 COD of water	Net COD Removal	gCOD/ h	gCOD/ m^2/	gCOD/ (KW)	kwh/ gCOD	Power Consumption
12.4	8.00	2.70	800	7.9	6.32	11.54	69.00	49.50	19.50	156.00	78.79	24.68	0.041	0.79
	8.00	2.70	900	8.35	7.52	11.59	69.00	50.60	18.40	147.20	74.34	19.59	0.051	0.94
	8.00	2.70	1000	8.66	8.66	11.54	69.00	49.30	19.70	157.60	79.60	18.20	0.055	1.08
	8.00	2.70	1100	8.98	9.88	11.59	69.00	53.60	15.40	123.20	62.22	12.47	0.080	1.23
	8.00	2.70	1200	9.31	11.17	11.55	69.00	41.70	27.30	218.40	110.30	19.55	0.051	1.40
	8.00	2.70	1300	9.66	12.56	11.57	69.00	47.70	21.30	170.40	86.06	13.57	0.074	1.57

A sewage treatment facility in a chemical industrial park in Yantai, Shandong Province, initially produces effluent with a COD of approximately 60mg/L, after a pre-treatment process that includes biochemical and Fenton treatments. High-energy electrolysis treatment further reduces the COD to below 40mg/L.

If required, it can be further controlled to achieve a stable value below 30mg/L.

2023.1.16 Experimental data										
2023.1.16 am	Raw water		900A 6T		1000A 6T		1100A 6T		1200A 6T	
COD	58.3	61.6	35.3	34.6	34.6	35.0	33.7	34.2	34.6	35.9
average value	59.9		35.0		34.8		34.0		35.3	
2023.1.16 pm	1200A 4T		1100A 4T		1000A 4T		900A 4T			
COD	23.6	27.2	27.6	26.3	27.6	28.9	29.8	29.4		
average value	25.4		27.2		28.3		29.6			

Landfill leachate concentrate

Membrane concentrated liquid COD(mg/L)	Result COD(mg/L)	Membrane concentrated liquid COD(mg/L)	Result COD(mg/L)
47000	Not Detected	4000	Not Detected

Pesticide wastewater (Item A)

Raw water COD(mg/L)	Process and Result COD(mg/L)			
127000	86000	37000	480	20

Pesticide wastewater (Item B)

Raw water COD(mg/L)	Process and Result COD(mg/L)			
146000	70500	31700	15400	1760

Pesticide wastewater (Item C)

Raw water COD(mg/L)	Process and Result COD(mg/L)			
212000	90100	65500	33540	200

Distilled wastewater

Raw water COD(mg/L)	Electrolyzed effluent COD(mg/L)	Evaporation water COD(mg/L)	Evaporation of mother liquor COD(mg/L)
82400	Not Detected	Not Detected	Not Detected

Evaporation of cellulosic wastewater mother liquor

MVR concentrated COD(mg/L)	Result COD(mg/L)	Raw wastewater COD(mg/L)	Result COD(mg/L)
431200	Not Detected	109500	Not Detected

Antioxidant wastewater

Raw water COD(mg/L)	Result COD(mg/L)
113000	Not Detected

Dyeing concentrate (hazardous wastewater)

Raw water COD(mg/L)	Result COD(mg/L)
413000	Not Detected

Wastewater from chemical material production company (Item 1)

Raw water COD(mg/L)	Result COD(mg/L)
213000	Not Detected

Wastewater from chemical material production company (Item 2)

Raw water COD(mg/L)	Result COD(mg/L)	Raw water COD(mg/L)	Result COD(mg/L)
3345	Not Detected	561	Not Detected

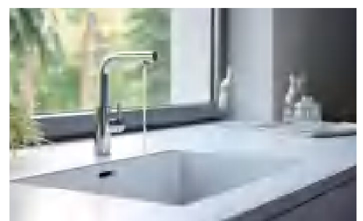
Application of ozone water produced by BDD in multiple fields

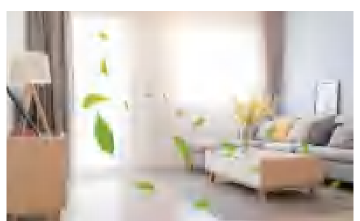
1. Application in water treatment of different uses

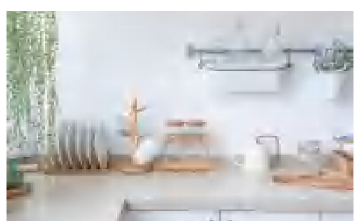
Drinking water: Ozone disinfection and sterilization does not have any residues harmful to the human body (such as carcinogenic halogenated organic matter produced by chlorine disinfection), which is very effective in improving the disinfection quality of drinking water.
Other water: The use of ozone to disinfect and sterilize swimming pool water is also very common abroad. After ozone disinfection and sterilization, the swimming pool water becomes clear and transparent, and the taste is fresh, which can solve the problems of irritation to the eyes and skin caused by traditional chlorine disinfection.
Household scenarios of ozone water: tap water system, indoor air purification, household appliances, washing machines, aquariums, beauty disinfection, pet cleaning and care.


drinking water

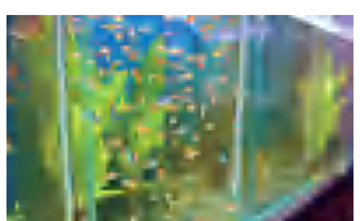

swimming pool


tap water system


indoor air purification


household appliances


washing machines

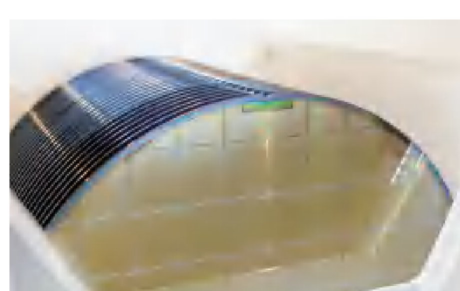

aquariums


beauty disinfection


pet cleaning and care

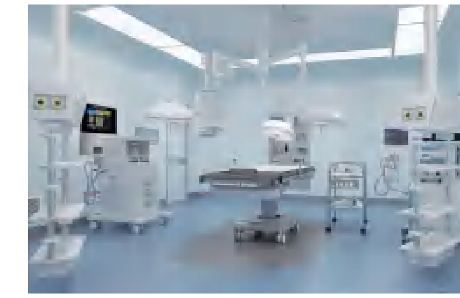
2. Application in the semiconductor industry

The ozone produced by BDD is mixed with water to form ozone water, which can be used to clean wafers. In addition, BDD electrolyzes sulfuric acid to produce peroxysulfuric acid, which can also be used in the resist (photoresist) removal process in semiconductor manufacturing.



3. Application in the medical and health field

The preparation of ozone water by BDD electrode is more efficient and convenient than the traditional ozone production method. Ozone water can disinfect the surfaces of medical equipment, instruments, beds, desktops, etc.; disinfect the air environment of wards, operating rooms, etc.; disinfect water quality such as medical water; treat drinking water, medical waste, etc.



4. Application in the food processing industry

Ozone can be used for food processing, equipment disinfection, packaging materials and container disinfection. Some food industry manufacturers in our country have begun to use ozone machines to disinfect and preserve production lines and products efficiently and quickly, and at the same time strictly disinfect the air in the production workshop.

5. Application in the agriculture industry

Pest control: In closed environments such as greenhouses, appropriate amounts of ozone can effectively prevent and control airborne and soil-borne diseases.
Soil purification and improvement: Ozone oxidizes and decomposes organic and inorganic matter in the soil, kills pathogens and pests, and promotes the reproduction of beneficial microorganisms and improves the soil microecological environment.
Irrigation water purification: Ozone can oxidize and decompose harmful substances such as organic matter, inorganic matter and pathogens in irrigation water to improve the quality of irrigation water.
Pesticide residue degradation: Ozone destroys the molecular structure of pesticides and effectively removes pesticide residues on the surface of fruits and vegetables.

6. Application in animal husbandry and aquaculture

The application of ozone in animal husbandry and aquaculture mainly includes air disinfection, water disinfection, feed and drinking water treatment, which can not only improve the disease resistance of livestock and poultry/aquatic products, improve the breeding environment, but also improve breeding efficiency and economic benefits.