As the world enters a new round of intensive technological innovation, the emerging technology-based marine industry has become a priority in the global economic recovery and social progress. As a large marine country, China attaches great importance to marine technology, highlighting it as one of the eight frontier technologies in The National Medium- and Long-Term Program for Scientific and Technological Development (2006-2020). To drive the innovation and development of marine technology, the government has also launched a number of national science and technology programs to support basic research, frontier technology, demonstration and application.

The recent years have seen a steady improvement of China's overall capacity of marine technological innovation. In ocean investigation and observation, China has launched several oceanographic satellites and put into use a full range of new cutting-edge marine equipment including high frequency surface wave radars, seafloor observatory equipment and Argo free-drifting profiling floats, achieving integrated observation from space, sea surface, underwater and seafloor. In marine science research, Chinese scientists have published a greater number of high-quality scientific papers. China has also developed a series of important technologies and equipment, including Jiaolong manned deep-sea submersible, 3,000m deep-water semi-submersible drilling rig, and investigation and development of ocean-floor solid mineral resources, which have promoted the shift of China's marine research from shallow coastal waters to deep open sea. As of the end of 2010, China's marine technological innovation had contributed 54.5% to its marine economy. The marine industry has been growing at above 20% annually, creating hundreds of thousands of jobs.

Looking forward, China will continue to build its marine technological innovation system, take an active part in international ocean research projects, and make contributions to the peaceful utilization of marine resources and the protection of marine ecosystems.
Preface

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DEEP-SEA EXPLORATION TECHNOLOGY AND EQUIPMENT

The deep sea is a frontier of international scientific research as well as a focal point of inner space research in the world. Deep-sea submersible technology and equipment are important means to explore deep-sea resources, conduct deep-sea scientific research, and carry out deep-sea engineering projects. To meet the need of deep-sea exploration, China has developed a series of deep-sea equipment and auxiliary equipment including manned submersible.
MANNED DEEP-SEA SUBMERSIBLE

With the support of various national science and technology programs, China has made great strides in the development of manned deep-sea submersible. Jiaolong manned deep-sea submersible reached a depth of 7,062 meters, setting a new dive record and bringing China to an international level in system integration, underwater acoustic communication, architectonics and navigation control. At present, a 4,500m manned submersible is under development. This submersible adopts extensive self-developed technologies including manned capsule, buoyancy material, acoustic positioning, thruster, hydraulic source and manipulator. This three-person submersible is expected to be completed in 2016.

CASE: Experimental application of Jiaolong manned submersible

In June 2012, China’s self-developed Jiaolong manned submersible successfully broke the threshold of 7,000 meters under the sea, reaching the maximum diving depth of 7,062 meters. It obtained for the first time valuable first-hand data about Mariana Trench 7,000 meters below the surface of the sea, and fully demonstrated the capability of seafloor exploration. In September 2013, Jiaolong completed its experimental voyage in northwest Pacific Ocean. In the three legs of the voyage, Jiaolong made 21 diving operations, collecting a lot of visible images and sample data for deep-sea scientific research. Stable equipment status and excellent physical state of the crew further proved Jiaolong’s suitability for scientific application.
REMO TELY OPERATED DEEP-SEA SUBMERSIBLE

China has developed a number of remotely operated submersibles and operation equipment with working depth ranging from dozens of meters to thousands of meters, including remotely operated submersible system, SJT-10 remotely operated submersible, ML-01 submarine cable layer, self-propelled submarine cable layer, Haiqian I and mine-hunting submersible, and achieved domestic production of key components.

CASE: Sea trial of 4500-meter Seahorse ROV

The 4,500-meter Seahorse remotely operated underwater vehicle (ROV) is currently China’s deepest unmanned remotely operated underwater vehicle. At present, Chinese researchers have made significant progress in key technologies including ROV mechanical structure, buoyancy material, hydraulic power and propeller, operating manipulator and tools, observation, communication and navigation, control software and hardware, floating and diving compensation mechanism and lifting mechanism, and completed the assembling, joint debugging and pool test of Seahorse ROV. In April 2014, Seahorse ROV completed 17 sea trials in South China Sea, including three trials in which it dove to the depth of 4,500 meters.
AUTONOMOUS UNDERWATER VEHICLE

China began R&D of autonomous underwater vehicles (AUV) in the early 1990s. In June 1997, the 10-hour 6,000-meter CR-01 AUV developed by Shenyang Institute of Automation (SIA) of Chinese Academy of Sciences in collaboration with other domestic and Russian institutes completed a deep-sea exploration in the Pacific Ocean. On this basis, SIA developed CR-02 AUV in collaboration with other institutes in late 1990s. From 2011, SIA improved and upgraded CR-02 AUV to form the new Submerged Dragon 1 AUV. The new AUV can perform a wide range of surveying and prospecting tasks including submarine microtopography and geomorphology precision surveying, sediment determination, submarine hydrological measurement, and submarine polymetallic nodule abundance measurement.

CASE: Mid-term sea trial of 50-300kg autonomous underwater vehicle

The 50-300kg AUV jointly developed by SIA, Xi'an Tianhe Defense Technology Co., Ltd. and Harbin Engineering University, is a small low-cost AUV developed as part of China’s submersible serialization strategy. It can dive to 1,000 meters with a maximum speed of 5 knots and an endurance of 36 hours at the speed of 2 knots. At present, this AUV has completed the mid-term sea trial.
CASE: Standardized mid-term sea trial of Haiyan underwater glider

Haiyan underwater glider developed by researchers at Tianjin University, which is 1.8 meters long, 0.3 meter in diameter and 70 kilograms in weight, has completed the standardized sea trial for mid-term evaluation. During the sea trial, Haiyan continuously operated for over 21 days, withstood adverse sea conditions of 4-meter-high waves, and recorded a total of 210 wave profiles. It had a total voyage of more than 600 kilometers, with the maximum working depth at 1,094 meters, the maximum gliding speed at 1.3 knots (nautical miles/hour) and the maximum horizontal moving speed at 3 knots.
DEEP-SEA TOPOGRAPHY AND GEOMORPHOLOGY HIGH-PRECISION EXPLORATORY EQUIPMENT

In the R&D of deep-sea topography and geomorphology high-precision exploratory equipment, China has made a series of major breakthroughs and achieved commercialization of sub-bottom profiler, synthetic aperture sonar, submerged multibeam sonar sounding system, and bathymetric sidescan sonar system (BSSS). A towed deep-water acoustics system has completed sea trial and will soon be delivered to its user.

CASE: DTA-6000 deep-tow acoustics system put into operation

The DTA-6000 deep-tow acoustics system developed by researchers from the Institute of Acoustics of the Chinese Academy of Sciences is able to acquire microtopographic data at seafloor at a depth of 6,000 meters, and perform surveys on underwater physicochemical parameters. The system can cover 500m-wide sounding and 700m-wide sidescan maximally, reaching an international advanced level with some technologies playing a leading role worldwide. The system finds promising applications in oceanology, submarine mineral resources survey and ocean engineering in the wake of serving as a conventional survey tool for Dayang-1 vessel to fulfill the intended tasks in the Pacific and the Atlantic.

DTA-6000 deep-tow acoustics system successfully performed a deep-tow acoustics survey in the hydrothermal area of 2,600-deep ocean ridge, marking the first application of the self-developed deep-tow acoustics system in the survey of mid-ocean ridge.

6000 high-resolution bathymetric sidescan sonar emerging from water

6000 high-resolution bathymetric sidescan sonar entering water
CASE: Successful application of synthetic aperture sonar (SAS)

SAS is applied to a wide range of domains, primarily in the detection and identification of underwater targets and buried underwater targets, high-resolution seabed mapping, underwater archaeology and target search. Researchers of the Institute of Acoustics of Chinese Academy of Sciences successfully developed the world’s first SAS with the capacity of both dual frequency and double-probe real-time imaging and became the first to perform real-time InSAS imaging, with various performance indicators ranking on the top globally. In 2012, the 14-day Zheng He Shipwreck Search was accomplished with a total voyage of over 1000km. Six shipwreck places were identified through high-precision scan of ten target areas.
OCEAN-FLOOR MINERAL PROSPECTING EQUIPMENT

China has grasped a series of key technologies of ocean-floor mineral prospecting. In addition to having extensive ocean-floor surface prospecting and sampling equipment including multipurpose drilling rigs capable of drilling up to a depth of more than 60 meters and bottom sediment fidelity samplers capable of reaching up to 30 meters, China has established an integrated natural gas hydrate development simulation research system.

**CASE: Abyssal-floor medium-length core drill**

China has grasped a series of key technologies in the development of abyssal-floor medium-length core drill, and completed the country’s first such drill with a maximum drilling depth of 20 meters, ten times deeper than the previous maximum depth. The core drill completed its first trial drilling in October 2010.

Abyssal-floor medium-length core drill

Samples obtained by the abyssal-floor medium-length core drill
CASE: Gastight sampler for deep-water sequential sampling

The gastight sampler for deep-water sequential sampling is able to perform time-sharing sampling of deep water (such as hydrotherm) and obtain high-fidelity samples of deep water. In the R&D of such deep-water sampling equipment, China has achieved significant progress. The sequential gastight sampler developed by Zhejiang University successfully gathered gastight cold spring samples in various tides though a two-day automatic sample laying test at the cold spring area of the Gulf of Mexico in March 2014. The equipment also obtained a large quantity of hydrothermal gas-tight samples at the hydrothermal area of Juan de Fuca Ridge in July 2014 by participating in the AT 26-12 and AT 26-17 voyages of US new Alvin manned submersible.
CASE: Cylindrical gastight natural gas hydrate sampling system

Zhejiang University has developed a cylindrical sampling system for gastight sampling of natural gas hydrate sediments. The highest pressure sampling record has been hit: the maximum length of non-gastight sample is 18.5m (9cm in diameter), and that of gastight sample is 14.2m (9cm in diameter). The gastight sample is the longest ever-known gastight sample in the world.
OFFSHORE OIL AND GAS DEVELOPMENT

In the early 21st century, the world entered into the marine era in oil and gas development. In this field, China has made rapid progress in both technology development and equipment manufacturing. At present, China is able to independently design and manufacture large-scale equipment for marine resource development. A number of heavy marine equipment including a 3,000-meter semi-submersible platform and a 3,000-meter pipe-laying ship has been put into use. They have substantially strengthened China’s technological capabilities in marine engineering and strongly promoted China’s offshore oil and gas industry in the deep sea. Moreover, China has systematically conducted technology research and laboratory simulation of prospecting and sampling of natural gas hydrates and provided strong technological support for the investigation and sampling of natural gas hydrates in the northern part of the South China Sea.
OFFSHORE OIL AND GAS EXPLORATION AND DEVELOPMENT

Among the continental shelves over which China exercises sovereignty and jurisdiction, there are approximately 700,000 square kilometers of petroliferous basins. According to estimates by relevant organizations, the South China Sea has huge reserves of oil. It is one of the top four waters rich in oil and natural gas, with oil in place accounting for one third of China’s total. Since 1996, with the continuous support of national science and technology programs, China has made a series of breakthroughs in key technologies and equipment manufacturing in offshore and deep-sea oil and gas prospecting and development, laying a solid technological foundation for the development of the offshore oil industry.

**CASE: China’s first 3,000-meter deep-water semi-submersible rig**

Researchers at CNOOC have mastered the design and part of the key manufacturing technologies of 3,000-meter deep-water semi-submersible rig after years of research and development. The technologies have been applied to the building of HYSY-981, China’s first deep-water semi-submersible rig. The rig is capable of well drilling, completion, workover and testing at a depth up to 3,000 meters and can be used in deep and open sea waters. The main technical indicators of the platform have reached international leading levels. The successful construction of HYSY-981 has significantly improved China’s ability in deep-water oil and gas exploration and development.
On September 15, 2014, CNOOC announced that its 981 drilling rig discovered high-yield hydrocarbons in the deepwater of northern part of South China Sea. It is China’s first major deepwater oil and gas discovery in Chinese waters.
**CASE:** Experimental application of polymer flooding EOR technology in Bohai Oilfield

Researchers at CNOOC Research Institute have solved for the first time the international challenge of exploiting offshore heavy crude oil through polymer flooding with the development of two upgraded pilot scale test products and EOR technologies based on salt-tolerant polymers, one online polymer dissolver, a complete assessment method of previous polymer flooding effect at Bohai Oilfield and the optimization plan for chemical agent for polymer flooding produced liquid treatment and the corresponding surface engineering. Field polymer injection test had been applied to the A7 and B7 well groups at Bohai Suizhong 36-1 Oilfield, forming 11 injection wells and 46 production wells. By the end of August 2010, the two well groups had increased a total oil production of 440,000 m³, reducing the water content by 430,000 m³ and delivering an input-output ratio of 1:2.63. It is estimated that the OIP at Bohai Oilfield suitable for polymer flooding development totals 1.42 billion m³ and the polymer flooding technology increases the recoverable reserve by about 0.1 billion tons, that is to say, several large oilfields with a capacity of over 100 million tons are discovered without additional exploration expenditure. The technology has great significance for easing China’s energy shortage.
**CASE:**  *Industrial application of drill-stem tester in oil and gas drilling*

Researchers at China Oilfield Services Limited (COSL) have developed a drill-stem tester in oil and gas drilling with proprietary intellectual property rights. The tester has been put into industrial application, making China the second country to master the cutting-edge drill-stem testing technology after the United States.
CASE: China’s first 3,000-meter deep-water pipe-lying crane vessel

Researchers at Offshore Oil Engineering Co., Ltd. (CDOEC) have developed a complete set of S-laying technologies suitable for working at a depth up to 3,000 meters underwater. The technology has been applied to the building of HYSY201, a 3,000-meter deep-water pipe-lying crane vessel. As indispensable equipment for deep-water oil and gas field development, HYSY201 can accomplish tasks such as lifting and dismantling the topside of oil rig among other bulky parts, jacket launching and installation and deep-water submarine pipeline laying and maintenance. HYSY201 has filled a gap in domestic deep-water pipe-lying equipment and boosted China’s deep-water oil and gas development capacity.
CASE: Integrated deep-water high-precision seismic exploration system

COSL has developed an integrated deep-water high-precision seismic exploration system with proprietary intellectual property rights. The system has been put into experimental application at Binhai 511 to perform the experimental operations in two 2D survey projects and one 3D survey project, having collected 558.53km² 2D seismic data and 173.38km² 3D data. The seismic data have proved the integrated deep-water high-precision seismic exploration system to be competent for offshore operation.
**CASE:** Submarine pipeline MFL detection robot system

Sinopec Shengli Petroleum Administrative Bureau has developed a Φ457 submarine pipeline MFL detector to handle the corrosion of oil and gas pipelines in the complicated submarine environment. The detector has been used to perform MFL detection for pipelines between Haisilian and Gudaoo No.1 Station of Shengli Oilfield in a field engineering application. Furthermore, technical research and design have been conducted for Φ219 and Φ273 detectors while standard laboratory furniture and comprehensive-function lab furniture among other supporting equipment have been developed. The detected defects have been collected and put into a data base.
CASE: Automatic vertical drilling system

The automatic vertical drilling system developed by researchers at Sinopec Shengli Petroleum Administrative Bureau creatively applied the advanced strapdown stabilization platform technology used in aerospace and aviation into the R&D of downhole instrument for oil-gas wells. The independently developed system has been applied to six wells and demonstrated leading performance. The system provides an effective way to solve technical problems when drilling on high steep structures and complex formations. The system delivers an average drilling speed at least twice that of the normal speed, bringing remarkable economic benefits by significantly reducing drilling costs.

CASE: Oceanic deep-water experimental tank

The oceanic deep-water experimental tank jointly developed by NDRC, Shanghai Municipal Development and Reform Commission, Shanghai Jiao Tong University and CNOOC can simulate not only various complicated marine situations for engineering tests, including 4,000m deep-water, unsteady wind, 3D wave and shear flow among others, but also hotspot waters in South China Sea, Gulf of Mexico, West Africa, Brazil and other places. It ranks the second globally in scale, function and equipment level. The experimental tank has played an important role in projects of offshore oil and gas development corporations, marine engineering study at research institutions and universities, as well as international cooperation projects. The tank provides an advanced testing environment for research, design, construction and application of deep-water oil and gas development engineering in China.
NATURAL GAS HYDRATE EXPLORATION AND DEVELOPMENT

Natural gas hydrate (also known as “flammable ice”) is a new mineral resource discovered in the 20th century. As a new clean energy source with high-efficiency and convenience to use, it is recognized as a strategic resource with prospects of commercial development in the 21st century. From the beginning of the 21st century when China started R&D of key technologies in exploring natural gas hydrate, China has developed a series of key prospecting technologies including high-precision seismic exploration, in-situ testing and fluid geochemistry and established an integrated natural gas hydrate prospecting system suitable for China’s offshore structures. In the coming years, China will continue to strengthen the resource investigation and evaluation of offshore and permanently frozen soil-based natural gas hydrate deposits and advance R&D in hydrate formation theory, prospecting, environmental impact assessment, and trial extraction. According to plans, China will commence natural gas hydrate drilling in its offshore waters in 2015.

CASE: Natural gas hydrate sampling

From 2007 to 2013, China obtained natural gas hydrate samples in Shenhua sea area in South China Sea and Pearl River Mouth Basin by utilizing an independently developed integrated natural gas hydrate detection system, which preliminarily proved China’s abundant natural gas hydrate reserves.
At present, China has put in place a full-featured marine environmental monitoring system, having developed more than 50 monitoring sensors of ocean dynamic elements and ecological elements, more than 40 marine monitoring platforms and 15 marine environmental monitoring technology systems. In addition to the integrated observation and testing networks in the Taiwan Straits and surrounding waters, and the northern waters of the South China Sea, China is constructing an ocean bottom stations in the coastal waters of Hainan and the East China Sea.
INTEGRATED MARINE ENVIRONMENTAL MONITORING SYSTEM

Since 2001 when it started R&D of integrated marine environmental monitoring systems, China has built an integrated marine environmental real-time monitoring network comprising onshore stations, free-drifting profiling floats, subsurface buoys, seabed bases, round wave radars and remote sensing satellites, and put into use a number of advanced systems including demonstration network data processing and decision support system, storm surge overflowing pre-warning and decision support system, red tide pre-warning system and offshore emergency response & decision support system, which have played an important role in typhoon disaster prevention and mitigation in recent two years.

CASE: Integrated marine environmental monitoring system

The integrated marine environmental monitoring system for critical waters independently built by Fujian Provincial Marine Environment and Fishery Resources Monitoring Center is China’s first and only integrated marine environmental monitoring system. Till now, several component forecasting systems have been set up and operating continuously for more than six months in experiment, including the global sea-surface wind forecasting system, the sea wave forecasting system, the ocean circulation forecasting system, the tide and tideway forecasting system, and the polar sea ice forecasting system. Among them, the global sea-surface wind forecasting system, the sea wave forecasting system, and the ocean circulation forecasting system have been officially put into operation and can provide forecasts on global sea-surface wind, sea waves, sea temperatures, ocean currents, tides and tideways, spring layers, and polar sea ice concentration for one to five days.

Schematic Diagram of the Integrated Marine Environmental Monitoring System in Shanghai Demonstration Zone

General Layout of the Integrated Taiwan Strait Marine Environmental Monitoring Network
MARINE ENVIRONMENTAL MONITORING EQUIPMENT

China has achieved great results in R&D of marine monitoring equipment, including the industrialization of two land-based high-frequency ground wave radar products, breakthroughs in key technologies of sky- and ground-wave radars, and development and putting into use of expendable bathymetograph (XBT), Argo free-drifting profiling floats (ARGO), fixed-point deep-sea mooring buoys, subsurface buoys, series of acoustic Doppler current profilers (ADCP), and series of prospecting and imaging sonars.

CASE: **High-frequency ground wave radar**

As an important means for measuring ocean current and sea surface slow-moving targets, the high-frequency ground wave radar is currently the only technology capable of synchronously measuring large areas of ocean currents. The portable OSMAR-S200 and array OSMAR071 high-frequency ground wave radars developed by researchers at Wuhan University in 2010 have been commercialized with proprietary IP and adopted in various government projects. The engineering prototype of the multifunctional variable-frequency high-frequency ground wave radar has been made and put on a preliminary sea trial.
**CASE: Underwater acoustic detector**

As a typical dual-use technology, the underwater acoustic technology has been widely applied in ocean acoustic communication, acoustic imaging, acoustic detection, underwater navigation and ocean environmental parameter measurement. China has obtained a series of product technologies such as the underwater Doppler ocean current profiler/log (ADCP), the phased array ocean current profiler/log (PAADCP), the acoustic correlation ocean current profiler/log (ACCP), and the deep sea lowered acoustic ocean current profiler (L-ADCP). A number of acoustic monitoring equipment prototypes with proprietary IP have passed long-term sea tests and reached the same level of similar foreign products, with a series of acoustic measurement products working at the shallow to 1,000-meter underwater range having already taken shape. The depth of ACCP tracking velocity measurement has exceeded 4,000 meters underwater, making China the second country to possess this technology in the world.
**CASE:** Deep and open sea internal wave observation network system

The first phase of the internal wave and hybrid precision observation network developed by the Ocean University of China was completed in 2013. Of the 23 sets of subsurface buoys deployed, six were recovered and 17 sets are in place and have obtained long-term continuous observation data. The data is the best and most systematic observation data with the longest internal wave time that China has obtained in the deep waters of South China Sea. In addition to leading to the creation of a standard system of deep-water subsurface buoy laying and recovery, the technology has been applied in multiple national projects.
**CASE:** Phased array three-dimensional acoustic and imaging sonar

As a new real-time three-dimensional image sonar, the phased array three-dimensional imaging sonar has a lot of advantages, including clear images, good real-time performance, and object detection and identification capability. The system prototype prepared by No. 715 Research Institute of China Shipbuilding Industry Corporation has finished sea tests, and all indicators have reached or surpassed the level of similar foreign products, making China the second county to possess this technology in the world. The system can conduct high-speed continuous shooting of static or moving objects within 200 meters in an opening angle of 50°×50° underwater and provide multiple observing angles. As a typical dual-use technology, the phased array three-dimensional acoustic imaging sonar has a broad application prospect in offshore engineering implementation, seaport wall inspection, submarine pipeline inspection, frogman detection, object identification, and obstacle avoidance and navigation of underwater vehicles.
MARINE ECOLOGY MONITORING TECHNOLOGY

China has made important progress in marine ecology monitoring technology. At present, it has completed the design of a dozen of marine ecology monitoring sensors and analyzers, demonstrated application of on-board integrated marine ecology (red tide, oil spill, sea ice, etc.) monitoring system, and established the Bohai Marine Ecology Monitoring & Demonstration System with satellite remote sensing and continuous fixed-point monitoring functions and the Shanghai Demonstration Zone for Red Tide Monitoring.

CASE: Marine red tide real-time monitoring and pre-warning system

On the basis of the national operation-oriented monitoring plan of red tide monitoring, researchers at the East China Sea Branch of State Oceanic Administration have built a more than 2,500 km²-marine demonstration area in Yangtze Estuary, where the red tide frequently appears and two land demonstration areas in Shengsi and Shanghai which are respectively the origin and aquiculture area of sea food. They have also established a set of integrated red tide monitoring system which is composed of satellites, ships, buoys, shore bases and red tide volunteers. With capacity to acquire real-time, continuous and stable monitoring data, this system has improved emergency response to red tide disasters.
**CASE:** Marine ecology monitoring and marine disaster pre-warning in Bohai Sea

Researchers at the North China Sea Branch of State Oceanic Administration have built and completed an integrated monitoring system and database for the Bohai Sea marine ecological environment, implemented the integrated management for Bohai Sea marine ecology monitoring data and thematic data from 2002 to 2013 and improved the ecological regime and marine disaster warning capacity of Bohai Sea to red tide, oil spill and sea ice, etc. through a variety of monitoring methods including the integrated on-ship system for rapid environmental monitoring, aerial remote sensing application system, satellite remote sensing application system, buoy monitoring system, sea ice radar monitoring system and routine monitoring system, etc.

![Interface of Integrated Software](image1)

![Water Sampling and Water Distribution](image2)

![Fujian Demonstration Network for Integrated Marine Real-time Monitoring](image3)
The Xiangyanghong 8 Carrying the Integrated System for Rapid Marine Ecology Monitoring
DEVELOPMENT AND UTILIZATION OF MARINE BIOLOGICAL RESOURCES

In marine biotechnology, overall China has kept pace with the international progress, reaching an internationally leading level in exploration of natural products. Up to now, China has discovered more than 3,000 new marine naturally occurring molecules, laying a solid foundation for subsequent innovative drug development. China has also made important progress in the development and application of marine oligosaccharides as agricultural agents, marine enzymes and marine living resources as pharmaceutical materials and developed a number of related products which have shown a huge market outlook.
HIGH-VALUE UTILIZATION OF MARINE BIOLOGICAL RESOURCES

China has achieved fruitful results in high-value utilization of marine living resources. At present, a good number of marine enzymes with prominent properties have been obtained, some of which (protease, lipase, esterase, lysozyme, etc.) have been applied in actual cases. China’s marine polysaccharide manufacturing technology has been industrialized, so have been a number of other technologies such as next-generation wound dressing with hemostatic, guaiaretic and antibacterial functions and surgical anti-blocking products. The development of marine oligosaccharides as agricultural agents has reached an internationally leading level and entered the phase of application and promotion. Moreover, a number of candidate vaccines with industrialization prospect have been under administrative examination and approval process, among which EdwardsiellatardaeIBAV/1 vaccine has passed the preliminary review.

**CASE: Marine oligosaccharide-based biopesticides and plant growth promoters**

The Dalian Institution of Chemical Physics under the Chinese Academy of Science has developed five new marine oligosaccharide-based biopesticides and plant growth promoting agents, which have been granted the formal certificate for biological pesticide registration and certificate for fertilizer registration and formed a production line for marine oligosaccharide products with an annual output of more than one kiloton. The marine oligosaccharide products have remarkable functions including disease resistance, cold resistance, growth promotion and environmental friendliness. The newly-developed products have been used in a pilot zone of 187,000 mu (1 mu =0.0667 hectares) in Shaanxi Province, increasing the yield of apples, crisp pears, grapes and watermelons per mu by 194kg on average.
**CASE:** Production of new marine micro-organism enzyme preparations

The Yellow Sea Fisheries Research Institute under the Chinese Academy of Fishery Sciences has mastered the scale preparation technology of the marine alkaline proteinase, lysozyme and lipase and established a production line for marine alkaline proteinase and esterase with total sales revenue of about RMB 1 billion. Assessment has proven that the dirt-removing power of the microthermal alkaline proteinase with high activity, good compatibility and strong stability is much stronger than that of the similar products of other foreign well-known enterprises, showing a huge market potential. The marine biological enzyme desquamation technology for hair-made article industry has decreased the discharge of traditional technology pollutant by about 90%, improved the pass rate of products from 50% to 95% and provided a reliable technological support for the clean production of this industry.
**CASE:** Certified production of marine organism-based medical hemostatic materials

The Ocean University of China has developed chitosan-based biomedical materials for surgical hemostasis, healing, anti-adhesion and completed the pilot scale production for high quality medical grade chitosan, fiber nonwoven agent, powder, gels, etc. Clinical research shows that the hemostasis and healing functions of the product are superior to those of similar products in foreign countries and two production approvals have been received.

**CASE:** Antarctic krill products

Nine research institutes including Liaoning Province Dalian Ocean Fishery Group of Corporations and Dalian Polytechnic University focused their attention on the Antarctic krill not yet developed in large scale, studied the rapid on-board separating technology and high-value comprehensive utilization technology, and produced the Antarctic krill meat, oil and other products. The Antarctic krill is rich in many nutrients such as astaxanthin, unsaturated fatty acid, amino acid, and active enzyme. The Antarctic krill oil is rich in EPA/DHA functional lecithin which has the function of brain protection, lipid lowering and immunity improvement.
China is among the first countries in the world to use marine living resources as drugs. In the 1980s and 1990s, China approved five commercial marine polysaccharide-based drugs. Since then, Chinese researchers have discovered a number of new lead compounds with novel structures and wide activity spectrum and are conducting systematic druggability evaluation and clinical research of more than 20 candidate drugs for major diseases, including five marine drugs which are under clinical research.

**CASE:** Screening of new marine microbial strains of active compounds

Researchers at Chinese institutions including the South China Sea Institute of Oceanology of the Chinese Academy of Sciences (CAS), CAS Shanghai Institute of Materia Medica, Nanjing University, Sun Yat-sen University and the Ocean University of China have screened out from the bottom sediments, seawater and marine organisms more than 2,000 active strains, extracted more than 600 new compounds and discovered more than 100 natural products and lead compounds with antineoplastic, antimicrobial, antioxidant or anti-HIV activity. These achievements have accumulated a plenty of precious marine microorganism resources for the development of innovative drugs and pesticide preparations, driven breakthroughs in the development of efficient fermentation techniques for the preparation of new active compounds like SZ-685C and supplied enough active compounds for subsequent clinical research.

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New Antineoplastic Compound SZ-685C

New Alkaloid with Strong Anti-HIV (HIV-1 RT) Activity
CASE: Marine drug candidates

The sea cucumber polysaccharide developed by Shanghai Kairun Biological Medicine Co., Ltd. for injection is the glycosaminoglycan freeze-dried powder injection extracted from the holothurialeucosplota. This sea cucumber polysaccharide used in the acute stage and recovery stage of ischemic stroke treating has already passed the Phase III clinical test. A production line with an annual output of 10 million injections has been established and successfully completed three groups of trial production. The anti-senile dementia oligosaccharide drug candidate 971 developed by Ocean University of China has been put into the Phase III clinic application and granted invention patents in eight countries (regions). The major preclinical study of drug candidate macrolides S completed by the Second Military Medical University shows that this compound has remarkable antineoplastic activity for lung adenocarcinoma, breast carcinoma and liver cancer, with no obvious intoxicating phenomenon found in animal experiment.

CASE: Marine plant capsule R&D and production

The CAS Institute of Oceanology mastered the key technologies of algal polysaccharides capsule like formulation optimization technology and formed film controlling, optimized the production process and key equipment, obtained the production approval of the SFDA as all the quality indexes conform to the existing standards, formulated two industrial standards, cooperated with other companies and established a full-scale production line with an annual output of 2 billion capsules. Algal polysaccharides and dietary fiber are the main ingredients of the capsule. Compared with traditional animal capsule, this capsule is of good stability, small loss on drying and low heavy mental content and can be used by groups with special requirements on drugs such as members with religions.
CULTIVATION OF COASTAL SALT-TOLERANT PLANT VARIETIES

With a large population, inadequate arable land, limited freshwater resources, and large areas of intertidal zones, China started very early in the research of seawater agriculture and has achieved a range of findings in breeding of salt-tolerant plants, planting of seaside mangroves, biological reclamation of highly polluted shallow waters, and vegetable planting and provision in extreme marine conditions in intertidal zones and for ships and warships.

CASE: Cultivation and promotion of over 10 new salt-tolerant plant varieties

Shandong Normal University, Institute of Soil Science of CAS, Sun Yat-sen University, Xiamen University and the CAS Institute of Botany, together with other R&D institutions, cultivated over 10 new coastal salt-tolerant plant varieties covering greening plants, energy plants, medicinal plant, vegetable and forage plants. Those new varieties were promoted in northern areas of Jiangsu and the Yellow River Delta in a combined area of up to 10,000mu, leading to remarkable economic, social and ecological benefits. Among those new varieties, the greening plant Althaea rosa has bright-colored flowers in tall and thick stalks, reaching 1.0% in salt tolerance; the cultivated cotton can be planted in 0.6% saline-alkali contained soil, with an yield increase of 20-50% compared to existing varieties; the cultivated new Jerusalem artichoke output can be raised by over 50% and the synanthrin production can also go up by 7-26% if irrigated with 30% seawater.
Bright Pink Deep-labeled Double Flower Althea Rosa – Salt-tolerance

Coastal Large-scale Salt-tolerant Jerusalem Artichoke

Coastal Large-scale Salt-tolerant Rape
Seawater desalination, i.e. producing freshwater by desalination of seawater, is a technology which provides a new source of freshwater and increases the supply of fresh water. Being not affected by time, space or climate and able to provide water with good quality at an increasingly reasonable price, this technology can ensure stable supply of drinking and industrial water in coastal areas. At present, China has grasped reverse osmosis desalination (SWRO) and low-temperature multi-effect distillation (MED) desalination technologies and is able to produce complete sets of 10,000-ton desalination equipment. A number of homemade desalination components including high-pressure reverse osmosis membrane, high-pressure circulating pump, pre-treatment membrane, and large-scale low-temperature multi-effect distiller have been put into use. China’s seawater desalination equipment has reached prevailing international levels in productivity, with single MED equipment desalting seawater 25,000 tons per day and single SWRO equipment 20,000 tons per day. The localization rate of parts and components in seawater desalination demonstration projects has reached approximately 85%. 
**CASE: The pilot project of Liuhengdao 10,000-ton seawater reverse-osmosis desalination**

The pilot project of Zhoushan Liuheng 10,000-ton seawater reverse-osmosis desalination (SWRO) led by Hangzhou Water Treatment Technology R&D Center Co., Ltd. completed the Phase I 20,000-ton civil infrastructure and 10,000-ton seawater desalination system in January 2010 and the second 10,000-ton seawater desalination system in May 2011. The single unit capacity, electricity consumption for per ton water, and localization rate of key equipment of the project all take lead in the same industry domestically and its engineering technology level is at an international advanced level.

Liuhengdao 10,000-ton SWRO Project

Phase I 20,000-ton/day SWRO Unit of Zhoushan Liuheng Water Company
CASE: Development and application of homemade SWRO membrane components

SROD membrane components independently developed by Hangzhou Water Treatment Technology R&D Center Co., Ltd. have been adopted in the Zhoushan Liheng 10,000-ton SWRO demonstration unit. During the 3-year service of the membrane system, all operation indexes such as desalination rate and water yield have been in good condition.
**CASE:** **High-pressure pump for sectional seawater desalination system**

The Research Center of Fluid Machinery Engineering and Technology of Jiangsu University developed a high-pressure pump for sectional seawater desalination system, which was first used in the 5,000-ton/day SWRO system of Liuheng Phase I demonstration project. Since November 2009 when it was put into operation, the pump has been in stable operation with lower energy consumption compared to the imported ones and can beat the best foreign seawater high-pressure pumps with same specifications as to efficiency indexes. The technology has been commercialized. In addition, high-pressure pumps for 10,000-ton and 15,000-ton seawater desalination units have also been developed and their prototypes are currently in the making. A series of seawater desalination high-pressure pumps and booster pumps are under development for subsequent commercialization.

**CASE:** **Promotion and application of 1,000-ton cartridge valve-controlled energy recovery equipment**

The 1,000-ton cartridge valve-controlled energy recovery equipment jointly developed by the Desalination and Membrane Technology Research Center of Tianjin University, Hangzhou Water Treatment Technology R&D Center Co., Ltd. and other institutions features a full range of independently developed key components and technologies on the basis of in-depth research of the energy transmission mechanism of large- and medium-sized energy recovery equipment, including four-way rotary valve, electro-hydraulic reversing valve, hydraulic operated valve, pressure exchange tube and reversing control system. According to test results, energy recovery reaches 97.7% when the seawater desalination unit operates at 65m³/h, reaching an international advanced level. The energy recovery technology and equipment have been applied extensively for medium and small seawater desalination projects in Tianjin, Qingdao, Zhoushan and other areas.
CASE: The pilot project of megawatt non-grid-connected wind-powered seawater desalination

Jiangsu Academy of Macroeconomic Research in collaboration with other research institutes established in 2011 a non-grid-connected wind-powered seawater desalination pilot plant with a capacity of 100-ton/day in a coastal area of Jiangsu. On this basis, a 5,000-ton/day megawatt non-grid-connected wind-powered seawater desalination pilot project was established in Yancheng, Jiangsu, with a direct freshwater production cost of RMB 4.2-5.4/ton.