

Global Protactinium-231 Supply, Demand and Key Producers, 2026-2032

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Abstracts

The global Protactinium-231 market size is expected to reach \$ 26.63 million by 2032, rising at a market growth of 9.3% CAGR during the forecast period (2026-2032).

In 2025, global Protactinium-231 production was approximately 89 grams, with a global average market price of around \$150,000 per gram. That year, total global production capacity for Protactinium-231 reached 150 grams, and the industry's average gross profit margin stood at 39%. Protactinium-231 is a long-lived radioactive isotope of the actinide element protactinium (atomic number 91, mass number 231). It has a half-life of approximately 32,800 years and primarily decays via alpha emission into actinium-227. Naturally occurring within the uranium-235 decay chain, it is one of the few significant long-lived radionuclides found in nature. Due to its long half-life, unique geochemical behavior, and relationship with uranium and thorium systems, ^{231}Pa is highly valuable in fields such as marine geochronology, paleoenvironmental research, nuclear physics experiments, radionuclide tracing, and nuclear fuel cycle studies. ^{231}Pa and thorium-230 (^{230}Th) are frequently employed in uranium-series dating systems; the $^{231}\text{Pa}/^{230}\text{Th}$ ratio is used to analyze marine sediment accumulation rates, paleoclimatic changes, and the history of ocean circulation. Furthermore, as protactinium is an actinide with complex chemical properties, the techniques for its separation, purification, and measurement present significant technical challenges; consequently, production and research are primarily conducted by national nuclear research institutions, isotope laboratories, and specialized scientific organizations.

The upstream sector of the ^{231}Pa industry chain primarily encompasses uranium resource development, nuclear fuel cycle processes, actinide separation technologies, and radiochemical preparation systems. Naturally occurring ^{231}Pa

Protactinium-231 (^{231}Pa) originates mainly from the ^{235}U decay chain and exists in trace amounts within uranium ores, nuclear fuel reprocessing waste streams, and related radiochemical systems. Given its extremely low natural abundance, commercial ^{231}Pa is generally not obtained through direct mining but rather through the processing of uranium ore samples, nuclear material separation workflows, or specialized radiochemical preparation methods. Production typically involves steps such as the processing of uranium-series materials, actinide separation, ion exchange, extraction chromatography, and high-purity refinement. Due to protactinium's unique chemical behavior—specifically its tendency to coexist in complex ways with elements like uranium and thorium during separation—advanced radiochemical expertise and precise analytical capabilities are required. The midstream sector of the industry chain primarily comprises nuclear research institutions, isotope laboratories, radiochemistry enterprises, and platforms supplying research materials; these entities are responsible for the further separation, purification, and quantitative analysis of Protactinium-231 (^{231}Pa), as well as the preparation of standardized products. As ^{231}Pa is a long-lived alpha-emitting radionuclide, midstream products typically take the form of research-grade solutions, standard reference sources, and samples representing specific chemical species. Production requires rigorous control over radionuclide purity, chemical purity, radioactivity, and long-term stability, with quality verification performed via techniques such as alpha spectrometry and mass spectrometry. Currently, ^{231}Pa is utilized mainly for scientific research rather than large-scale industrial commercial supply; its distribution relies primarily on research project collaborations, custom laboratory orders, and the provision of certified reference materials. Downstream applications of ^{231}Pa are concentrated in fields such as earth sciences, environmental research, nuclear physics, and radioactive tracing. The most established application is the $^{231}\text{Pa}/^{230}\text{Th}$ uranium-series dating technique, which is widely employed for dating marine sediments, reconstructing paleo-oceanic environments, studying glacial-period climates, and analyzing the global carbon cycle. Given that the migration behavior of ^{231}Pa in the ocean is closely linked to particle settling processes, it serves as a valuable tool for investigating marine particle transport, sedimentation rates, and paleo-environmental changes.

Protactinium-231 (^{231}Pa) and thorium-230 (^{230}Th) together form a crucial geochronological system within the uranium series; the $^{231}\text{Pa}/^{230}\text{Th}$ ratio is widely used to study marine sedimentation processes, paleoceanographic environmental changes, glacial-interglacial climate evolution, and the history of the global carbon cycle. Due to its long half-life (approximately 32,800 years) and unique adsorption behavior regarding marine particles, ^{231}Pa can record sediment transport and changes in ocean circulation over long timescales, making it indispensable in

paleoclimate research, deep-sea exploration, and Earth system science. As research into global climate change, polar scientific expeditions, and deep-sea resources advances, the growing demand for high-precision radioisotope dating techniques will provide stable support for the supply of research-grade Pa-231.

Pa-231 is a typical long-lived actinide radionuclide; its unique nuclear structure and chemical behavior make it a key subject for studying actinide migration patterns, nuclear reaction data, and the long-term evolution of radioactive waste. In fields such as advanced nuclear fuel cycles, nuclear waste safety assessment, and environmental radioactivity monitoring, researchers rely on long-lived radionuclides like Pa-231 to analyze the migration pathways and stability of radioactive elements in geological environments. Furthermore, the development of advanced nuclear energy technologies and stricter safety management requirements for nuclear materials are driving increased investment in the study of long-lived radionuclide behavior, thereby promoting the application of Pa-231 in nuclear chemistry, environmental nuclear science, and fundamental physics research.

Given its extremely low natural abundance and its coexistence with elements such as uranium and thorium in uranium-series materials, the preparation and purification of Pa-231 present significant technical challenges. Future industry development will focus on enhancing actinide separation efficiency, optimizing ion-exchange and extraction chromatography processes, minimizing sample processing losses, and improving product quality control through advanced detection techniques such as high-resolution mass spectrometry and alpha spectrometry. Simultaneously, the development of automated radiochemistry experimental platforms and standardized operating procedures promises to reduce the cost of preparing Pa-231 research samples, improve supply stability, and facilitate the transition from small-scale laboratory production to the supply of specialized research-grade materials.

Report Scope

This report studies the global Protactinium-231 production, demand, key manufacturers, and key regions.

This report is a detailed and comprehensive analysis of the world market for Protactinium-231 and provides market size (US\$ million) and Year-over-Year (YoY) Growth, considering 2025 as the base year. This report explores demand trends and competition, as well as details the characteristics of Protactinium-231 that contribute to

its increasing demand across many markets.

Highlights and key features of the study

Global Protactinium-231 total production and demand, 2021-2032, (Gram)

Global Protactinium-231 total production value, 2021-2032, (USD Million)

Global Protactinium-231 production by region & country, production, value, CAGR, 2021-2032, (USD Million) & (Gram), (based on production site)

Global Protactinium-231 consumption by region & country, CAGR, 2021-2032 & (Gram)

U.S. VS China: Protactinium-231 domestic production, consumption, key domestic manufacturers and share

Global Protactinium-231 production by manufacturer, production, price, value and market share 2021-2026, (USD Million) & (Gram)

Global Protactinium-231 production by Type, production, value, CAGR, 2021-2032, (USD Million) & (Gram)

Global Protactinium-231 production by Application, production, value, CAGR, 2021-2032, (USD Million) & (Gram)

This report profiles key players in the global Protactinium-231 market based on the following parameters - company overview, production, value, price, gross margin, product portfolio, geographical presence, and key developments. Key companies covered as a part of this study include ORNL, Orano, Rosatom, CNNC, CERN, JAEA, Eckert & Ziegler, LANL, HZDR, etc.

This report also provides key insights about market drivers, restraints, opportunities, new product launches or approvals.

Stakeholders would have ease in decision-making through various strategy matrices used in analyzing the World Protactinium-231 market

Detailed Segmentation:

Each section contains quantitative market data including market by value (US\$ Millions), volume (production, consumption) & (Gram) and average price (US\$/g) by manufacturer, by Type, and by Application. Data is given for the years 2021-2032 by year with 2025 as the base year, 2026 as the estimate year, and 2027-2032 as the forecast year.

Global Protactinium-231 Market, By Region:

United States

China

Europe

Japan

South Korea

ASEAN

India

Rest of World

Market Segmentation

Global Protactinium-231 Market, Segmentation by Type:

Nuclear Reactor Production

Natural Uranium Extraction

Global Protactinium-231 Market, Segmentation by Product Form:

Protactinium-231 Solution

Protactinium-231 Radioactive Source

Protactinium-231 Compound

Global Protactinium-231 Market, Segmentation by Purity Grade:

Research-grade Protactinium-231

Industrial-grade Protactinium-231

Global Protactinium-231 Market, Segmentation by Radioactivity:

Low-activity Protactinium-231

Medium-activity Protactinium-231

High-activity Protactinium-231

Global Protactinium-231 Market, Segmentation by Application:

Nuclear Physics Research

Thorium Fuel Cycle Experiments

Medical Isotope Research

Companies Profiled:

ORNL

Orano

Rosatom

CNNC

CERN

JAEA

Eckert & Ziegler

LANL

HZDR

Key Questions Answered

1. How big is the global Protactinium-231 market?
2. What is the demand of the global Protactinium-231 market?
3. What is the year over year growth of the global Protactinium-231 market?
4. What is the total value of the global Protactinium-231 market?
5. Who are the Major Players in the global Protactinium-231 market?
6. What are the growth factors driving the market demand?

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