



Gadolinium Fact Sheet

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What is gadolinium?

Gadolinium is a silvery white, malleable and ductile **rare earth metal** with a metallic luster. It crystallizes in hexagonal, close-packed alpha form at room temperature; when heated to 1508 K, it transforms into its beta form, which has a body-centered cubic structure.

Unlike other rare earth elements, gadolinium is relatively stable in dry air; however, it tarnishes quickly in moist air and forms a loosely adhering oxide that spalls off and exposes more surface to oxidation. Gadolinium reacts slowly with water and is soluble in dilute acid.

Gadolinium has the highest thermal neutron capture cross-section of any (known) element, 49,000 barns, but it also has a fast burn-out rate, limiting its usefulness as a nuclear control rod material.

Gadolinium becomes superconductive below a critical temperature of 1.083 K. It is strongly magnetic at room temperature, and exhibits ferromagnetic properties below room temperature.

Gadolinium demonstrates a magnetocaloric effect whereby its temperature increases when it enters a magnetic field and decreases when it leaves the magnetic field.

Gadolinium is not found naturally in any form in the human body. To be present in the body, it must be injected or ingested.

What is gadolinium used for?

Gadolinium is used for making gadolinium yttrium garnets, which have microwave applications, and gadolinium compounds are used for making phosphors for color TV tubes. Gadolinium is also used for manufacturing compact discs and computer memory.

Gadolinium is used in nuclear marine propulsion systems as a burnable poison. The gadolinium slows the initial reaction rate, but as it decays other neutron poisons accumulate, allowing for long-running cores. Gadolinium is also used as a secondary, emergency shut-down measure in some nuclear reactors, particularly of the CANDU type.

Gadolinium also possesses unusual metallurgic properties, with as little as 1% of gadolinium improving the workability and resistance of iron, chromium and related alloys to high temperatures and oxidation.

Because of their paramagnetic properties, solutions of organic gadolinium complexes and gadolinium compounds are used as intravenous radiocontrast agents to enhance images in medical magnetic resonance imaging.

Besides MRI, gadolinium (Gd) is also used in other imaging. In X-ray, gadolinium is contained in the phosphor layer suspending in a polymer matrix at the detector. Terbium-doped gadolinium oxysulfide ($Gd_2O_2S: Tb$) at the phosphor layer is to convert the X-rays releasing from the source into light. Gd can emit at 540nm (green light spectrum = 520 – 570nm), which is very useful for enhancing the imaging quality of the X-ray that are exposed to the photographic film. Beside Gd's spectrum range, the compound also has a K-edge at 50 kiloelectron volt (keV), which means its absorption of X-ray through photoelectric

interactions is great. The energy conversion of Gd is up to 20%, which means, one-fifth of the X-ray striking on the phosphor layer can be converted into light photons.

Gadolinium oxyorthosilicate (GSO) is a single crystal that is used as a scintillator in medical imaging equipment like as Positron Emission Tomography (PET). Another new scintillator for detecting neutron is cerium-doped gadolinium orthosilicate (GSO - $\text{Gd}_2\text{SiO}_5:\text{Ce}$).

Gadolinium gallium garnet ($\text{Gd}_3\text{Ga}_5\text{O}_{12}$) is a material with good optical properties, and is used in fabrication of various optical components and as substrate material for magneto–optical films.

What is the disease gadolinium causes?

Nephrogenic Systemic Fibrosis (NSF), also known as **nephrogenic fibrosing dermopathy (NFD)**, is a condition that, so far, has occurred only in people with kidney disease.

There were no cases identified prior to early 1997. NSF is a systemic disorder with its most prominent and visible effects in the skin. For this reason, Nephrogenic Systemic Fibrosis has been suggested as an equivalent terminology in those previously diagnosed with NFD, and is preferred in that it more accurately reflects our current understanding of the disorder.

Neither the duration of kidney disease nor its underlying cause are related to the development of NSF. Some patients with NSF develop skin tightening in the earliest stages of kidney disease, and others may have had kidney disease for years.

NSF appears to affect males and females in approximately equal numbers. NSF has been confirmed in people of all ages, including children, and ethnic background does not appear to be a factor.

Symptoms. Patients with NSF describe swelling and tightening of the skin, usually limited to the extremities but sometimes involving the trunk. The condition may develop over a period of days to several weeks. In many cases, the skin thickening inhibits the flexion and extension of joints, resulting in contractures. Severely affected patients may be unable to walk, or fully extend the joints of their arms, hands, legs, and feet. Complaints of muscle weakness are common.

The skin changes may start as reddened or darkened patches, papules, or plaques. In time, the skin may feel “woody” and the surface may resemble the texture of the peel of an orange. Patients may experience burning, itching, or severe sharp pains in areas of involvement. Radiography may reveal calcifications of the soft tissue. Deep “bone pain” has been described in the hips and ribs.

The skin lesions are commonly symmetrical, with zones between the ankles and thighs most commonly involved, followed by involvement between the wrist and upper arms. Hand and foot swelling with blister-like lesions has also been reported. Some patients have reported yellow papules or plaques on or near the eyes. Rapid, new onset fluctuating hypertension of unknown cause has been described prior to the onset of the skin lesions.

Treatment. **There is no consistently successful treatment for NSF,** although improving renal function (by any means) seems to slow or arrest NSF (and in many cases allows for gradual reversal of the process over time).

Treatments that have been tried and continue to be investigated include: oral steroids (prednisone), topical Dovonex (under occlusion), extracorporeal photopheresis (ECP), plasmapheresis, Cytoxan, Thalidomide, ultraviolet therapy, Physical therapy, Pentoxifyllin, high dose Intravenous Ig therapy, and renal transplantation

Prognosis. Because NSF is a rare, relatively recent diagnosis, the natural history of the disease is not well understood. Some patients report a gradual improvement in mobility and slight softening of the skin over time. Complete spontaneous healing in a patient with ongoing kidney disease has not been reported.

Several patients with NSF have died as a result of complications of their kidney disease or transplant

surgery. One patient, who elected to discontinue dialysis, had widespread fibrosis involving the diaphragm, psoas muscles, proximal esophagus and intimal areas of vessels of the kidney and lungs.

Some patients with NSF (estimated at 5% or less) have an exceedingly rapid and fulminant disease course that may result in death. NSF, by itself, is not considered fatal, but it can contribute to causing death by restricting effective ventilation, by restricting mobility to the point of causing an accidental fall that may be further exacerbated by fractures and clotting complications, and by other means.

Why are only people with kidney impairment at risk?

At this time, the only people known to be at risk are those:

1. who had gadolinium injected in connection with an MRI (magnetic resonance imaging) scan or an MRA (magnetic resonance angiography). Gadolinium is FDA approved for MRI but not MRA.
2. who, at the time of MRI or MRA, had kidney failure or kidney function problems. Many will have been on dialysis, but some might have kidney problems they didn't or don't know they had.

If there is an NFS or NFD diagnosis, there is a case, irrespective of whether the person knows of a history of kidney problems.

Gadolinium is poisonous. To protect the body from direct contact with gadolinium used in injections, the gadolinium in the solution is chemically combined with chelates. Different manufacturers have different patented compounds with different molecular structures.

In a person with normally functioning kidneys, gadolinium is eliminated from the body is less than two hours, and the chelate compounds are stable for at least this long. However, in people with kidney impairment, it might take up to 36 hours to eliminate gadolinium. During this amount of time, the chelate compound becomes unstable in the sense that the chelates have a stronger attraction for substances in the body, particularly iron, that for gadolinium, and as time goes on, the chelates break their bond with gadolinium and attach to these other substances, leaving the body unprotected from the gadolinium.

Who makes gadolinium compounds used in diagnostic imaging?

Maker	Maker's US HQ	Trade name	Generic name
General Electric	Fairfield CT	Omniscan	gadodiamide
GE Healthcare (formerly Amersham)	Piscataway NJ	Same as GE	Same as GE
Bayer	Pittsburgh PA	Magnevist	gadopentetate
Bayer Healthcare	Wayne NJ	Same as Bayer	Same as Bayer
Bayer	Pittsburgh PA	Gadovist	gadobutrol
Bayer	Pittsburgh PA	Vasovist	gadofosveset
Tyco Healthcare	Princeton NJ	Optimark	gadoversetamide
Bracco Diagnostics	Princeton NJ	MultiHance	gadobenate
Bracco Diagnostics	Princeton NJ	ProHance	gadoteridol

How does one find out which compound was used for a person's injection?

A potential client will almost never know this. It might or might not show up in a person's medical records. The one place it will be is in the accounting records of the hospital or other facility where the MRI or MRA was done, showing what company the hospital or other facility paid for the contrast medium used in the scan.