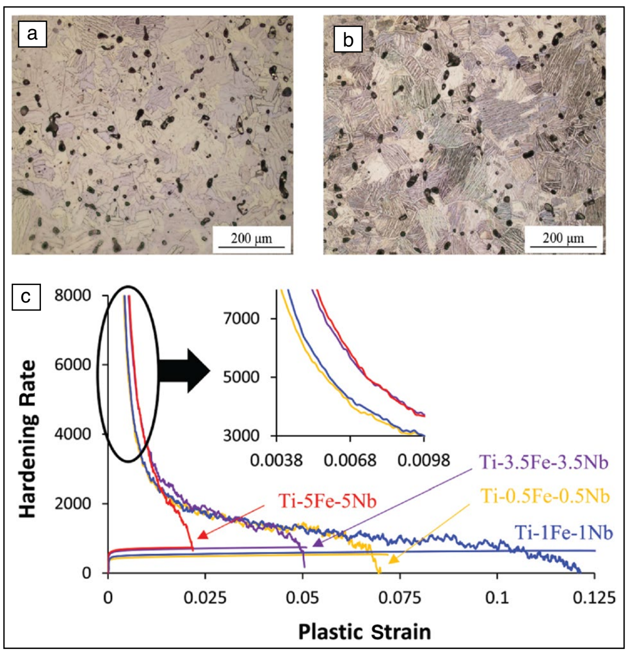
Ternary Ti–Mn–Nb alloys produced via powder metallurgy

Titanium and its alloys exhibit exceptional specific strength, toughness, biocompatibility, and corrosion resistance making them ubiquitous in biomedical applications for orthodontic and orthopedic implants and for military applications for aircraft and spacecraft. The most widely used commercial titanium alloy is an alpha–beta phase alloy containing 6% aluminum and 4% vanadium, widely referred to as Ti-6Al-4V. Alternatively, titanium can be alloyed using either a eutectoid or isomorphous beta stabilizing element to produce a binary alloy. Researchers have now examined the resulting properties of combining both elements. As reported in a study recently published in *Scientific Reports* (https://doi.org/10.1038/s41598-023-28010-7), the new ternary titanium alloys with added eutectoid and isomorphous beta stabilizing elements, manganese and niobium, respectively, were produced via powder metallurgy.



Optical micrographs showing microstructure of the ternary Ti–*x*Mn–*x*Nb alloys with different amounts of stabilizing elements: (a) Ti–0.5Mn–0.5Nb, (b) Ti–5Mn–5Nb; (c) the hardening rate of the ternary Ti–*x*Mn–*x*Nb alloys. Credit: *Scientific Reports*.

"We aim to achieve a compromise of good strength and ductility by producing alpha–beta alloys," says Leandro Bolzoni of the University of Waikato in New Zealand and team leader on the project. Alpha-titanium alloys are known to be strong yet less ductile, whereas β-titanium alloys are more ductile with good formability.

In the study, powder-blended titanium-manganese-niobium with varying amounts of manganese and niobium in low concentrations (0.5, 1, 3.5, and 5 wt%) were manufactured by cold pressing and subsequent consolidating at 1300°C. The resulting ternary alloys are characterized by a lamellar microstructure of equiaxed alpha-titanium grain boundaries and alpha–beta lamellae.

The mechanical behavior of the alloys was also evaluated. It was found that there is an increase in the ultimate tensile strength and hardness with increasing alloying element concentrations. In contrast, alloys with the lowest concentrations of manganese and titanium have the highest ductility. Compared to binary titanium alloys for the same amount of beta stabilizers, the new ternary alloys have higher and lower yield strength than titanium-niobium and titanium-manganese alloys, respectively.

"Although further studies are required, the new ternary titanium alloy provides a potential replacement to Ti-6Al-4V for biomedical applications," Bolzoni says. "Aluminum can be [a] neurotoxicant, hence linked to Alzheimer's disease, while vanadium is cytotoxic, thus poisonous to living cells," he says. On the other hand, niobium is less cytotoxic than other alloying elements and biocompatible with good corrosion resistance when added to titanium. In addition, manganese in controlled quantity is essential in osteogenesis and helps in bone resorption.

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