

# Imaging of macrophages using nanoparticle atherosclerosis

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## ABSTRACT

Macrophages (M) play a crucial role in atherosclerosis, and M markers, such as CD68 and MAC-3, have a strong correlation with the severity of lesions and treatment modulation. We have created a novel Positron Emission Tomography (PET) agent with improved pharmacokinetics to enable in vivo imaging at tracer doses, based on the avidity of lesional M for polysaccharide-containing supramolecular structures like nanopartic-

les. The science and engineering behind the design, synthesis, characterisation, and use of materials and devices whose smallest functional organisation, in at least one dimension, is on the nanoscale scale, or one billionth of a metre, is known as nanotechnology. As a result of its ability to influence the fundamental molecular structure, which allows control over the macroscopic chemical and physical properties, consideration of individual molecules and interacting groups of molecules in relation to the bulk macroscopic properties of the material or device becomes significant at these scales.

**Key Words:** *Atherosclerosis; Nanoparticle*

## INTRODUCTION

Atherosclerotic plaque evolution is fueled by inflammation, which raises cardiovascular risk. Foam cells, a distinguishing feature of atheromata, are produced when monocytes/macrophages (M) enter developing atherosclerotic lesions, consume modified lipoprotein particles, and do so M may weaken the fibrous cap of the plaque by secreting proteases, which can also increase local inflammation by the release of cytokines and reactive oxygen species. Because of this, M function as protagonist cells that can promote plaque disintegration and destabilise inflammatory atherosclerotic plaques, which are frequent causes of myocardial infarction and stroke.

Based on their active internalisation and intracellular entrapment into phagocytic cells, a variety of carbohydrate and polyol-coated Nanoparticles (NP) have become effective affinity labels for M. For instance, NP has been employed in MRI studies to report carotid artery plaques in people and areas of inflammatory lesions in animals. Despite the unmatched adaptability and soft tissue contrast offered by MRI, direct abnormality visualisation frequently necessitates quite high NP (2–20 mg Fe/Kg) concentrations. Positron Emission Tomography (PET), a nuclear imaging technology, may offer detection sensitivities that are an order of magnitude higher than those allowed by MRI, allowing the use of NP at lower doses. Furthermore, hybrid imaging offers the ability to map signal to atherosclerotic vascular regions due to the great sensitivity of PET and the anatomical information offered by CT. However, imaging in tiny vessels like coronary arteries may still be difficult with current PET imaging equipment' resolutions.

The size of the artery lumen or the composition of the plaque have been the main subjects of conventional imaging of atherosclerosis. Inflammation has been discovered as a critical mechanism influencing lesion initiation, development, and complications as a result of advances in the molecular and clinical biology of

atherosclerosis. The endeavour to imaging inflammation in atheroma has increased significantly as a result of this recognition. The use of nanotechnology gives fresh ideas for creating diagnostic agents. Nanoparticles have been used in magnetic resonance imaging and optical imaging.

But the development of new generations of PET imaging agents has only lately been investigated using this technique. In this work, we discuss the creation and evaluation of a brand-new, adaptable nanoparticle platform for PET imaging. The combination of dextran coated nanoparticles' strong intrinsic phagocytic avidity and their derivatization with a radiotracer results in a highly sensitive method for determining the M burden in mouse atherosclerotic lesions. Additionally, Cu-tri-modal TNP's nature enables hybrid imaging and thorough probe validation using fluorescence-based methods at the cellular and molecular levels.

Creating methods to recognise inflammatory, likely rupture-prone atherosclerotic plaques has become increasingly popular in clinical settings. Such functional imaging may make it possible to identify people who are at high risk and assist guide treatment to prevent cardiovascular events.

High sensitivity, high specificity for biological processes leading to plaque rupture, and practicability are goals for a viable device.

In the biomedical field, Ag-Au bimetallic NPs are gaining more attention than individual AgNPs and AuNPs due to their antibacterial activity, and in electrochemical studies because of their improved catalytic activity, surface area, and electron transfer.

Nanoparticle probes can give imaging techniques improved spatial resolution, increased signal sensitivity, and the capacity to communicate information about biological systems at the molecular

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and cellular levels. Magnetic Resonance Imaging (MRI) contrast enhancement probes can be made from basic magnetic nanoparticles. The addition of other functional moieties, such as fluorescent tags, radionuclides, and other biomolecules, can subsequently be made to these magnetic nanoparticles as a fundamental platform for multimodal imaging, gene delivery, and cellular trafficking. Target cells can be found using an MRI that uses hybrid magnetic nanoparticle-adenovirus probes to monitor optically the delivery of genes and the expression of green fluorescent proteins.

Nuclear methods like Positron-Emission Tomography (PET) may be able to identify particles at lower concentrations than conventional MRI allows thanks to their potentially superior detection sensitivity. Furthermore, hybrid imaging offers the ability to map signals to atherosclerotic vascular regions due to the great sensitivity of PET and the anatomical information offered by Computed Tomography (CT). The accumulation of the contrast agent in the target location is always necessary for molecular imaging, and this can be done more effectively by directing nanoparticles that contain the contrast agent toward the target. Targeting groups must be used in order to access target molecules that are obstructed by tissue barriers. Signal amplification is offered by nanoparticles with numerous contrast groups for imaging modalities with low sensitivity. In theory, the same nanoparticles can deliver both the contrast agent and the medication, enabling simultaneous monitoring of the biodistribution and therapeutic activity.

These nanofiber-based scaffolds come in a variety of pore size distribution, porosity levels, and surface area to volume ratios. A basis for the future optimization of an electrospun nanofibrous scaffold in a tissue-engineering application is also provided by the wide range of parameters, which are favourable for cell attachment, growth, and proliferation.