دومین کنگره پلاسما پزشکی ایران
The 2nd Congress on Plasma Medicine
DECEMBER 11-12,2025
۲۱ و ۲۰ آذر ماه ۱۴۰۴
دبیرخانه دائمی کنگره پلاسما پزشکی ایران
www.plasmamedsym.ir

Nanomaterial-Assisted Cold Atmospheric Plasma Therapy: Advances in Targeted Cancer Treatment

Mobina Bagherian[1], Hadiseh Vahabi[2], Mahdi Moassesfar[3], Amirmahdi Panzaei[1], Monireh Ajami[1*]

[1]Department of Medical Laboratory Sciences,TeMS.C., Islamic Azad University, Tehran, Iran
[2]Student Research Committee, Department of Medical Laboratory Sciences, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Department of Biosciences, University of Milan, Milan, Italy

OPEN ACCESS

Citation:
Bagherian M, Vahabi H, Moassesfar M, Panzaei A, Ajami M. Nanomaterial-Assisted Cold Atmospheric Plasma Therapy: Advances in Targeted Cancer Treatment. *Iran Biomed J.* Supplementary (2-2026): 60.

ABSTRACT

Introduction: Nanomaterial-assisted cold atmospheric plasma (CAP) therapy has emerged as a promising strategy in oncology by enhancing the selectivity, depth of delivery, and availability of reactive species in plasma-based treatments. CAP generates reactive oxygen and nitrogen species (RONS), ultraviolet photons, and charged particles that selectively damage malignant cells, The incorporation of nanomaterials further improves treatment precision. This study aimed to summarize recent advances in nanomaterial-enhanced CAP systems, highlight their mechanisms of synergistic anti-tumor activity.

Materials and Methods: A systematic search of PubMed, Scopus, and Web of Science was conducted for studies published from 2015 to 2025. Search terms included “Plasma Gases”, “Nanoparticles”, “Drug Delivery Systems”, “Reactive Oxygen Species”, and “Neoplasms”. Inclusion criteria comprised original and review studies investigating CAP combined with nanomaterials for cancer treatment. Exclusion criteria were conference abstracts and studies unrelated to nanomaterial-assisted CAP.

Results and Discussion: Across the studies reviewed, nanomaterials improved RONS stability, tumor penetration, and targeted delivery, enhancing CAP-induced oxidative stress, DNA damage, and apoptosis. Various forms of nanocarriers, such as hydrogels, microneedles, and catheter-based systems, enabled localized or deep-tissue delivery of CAP-activated agents. Combination approaches demonstrated amplified anti-tumor mechanisms, including mitochondrial dysfunction, immunogenic cell death, ferroptosis, pyroptosis, and autophagy modulation. Preclinical evidence showed enhanced tumor suppression in models of melanoma, glioblastoma, breast, lung, pancreatic, and ovarian cancers, with improved synergy observed when CAP was paired with chemotherapeutic-loaded nanomaterials.

Conclusion: Nanomaterial-assisted CAP significantly strengthens plasma-driven cytotoxicity and targeted delivery, offering a powerful platform for next-generation cancer therapy. Future work should optimize nanomaterial–CAP interactions and facilitate clinical translation.

Keywords: Drug delivery systems, Nanoparticles, Neoplasms, Plasma gases, Reactive oxygen species

Corresponding Author: Monireh Ajami
Department of Medical Laboratory Sciences,TeMS.C., Islamic Azad University, Tehran, Iran; E-mail: monirehajami@iau.ac.ir