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Preface

In the past ten years, one of the most important emerging multidisciplinary areas in nanotechnology has been cancer nanotechnology, which aims at developing nanoscale solutions to longstanding problems in cancer managements including therapy and diagnosis. New nanomaterials- and nanotechnology-based functional structures, designs, devices, and systems are proposed and used to directly tackle problems related to cancer. This has formed several subareas like therapeutic cancer nanotechnology, drug delivery and release cancer nanotechnology, diagnostic cancer nanotechnology, imaging cancer nanotechnology, biomolecular cancer nanotechnology, nanostructured biomaterials and bio-inspired nanomaterials for cancer therapy and diagnosis, and translation cancer nanotechnology, integrated systems for multifunctional applications in cancer therapy and diagnosis.

Cancer has become the leading cause of human death in China and other countries. According to a recent report of the World Health Organization, there are 15 million new cancer patients per year, and cancer causes 6 million deaths every year worldwide. In the past 50 years, researchers have investigated and discovered new anticancer agents for more successful cancer treatments. However, the progress in cancer treatment is very slow and inefficient. It is unlikely for a significant increase in the cure rate to be achieved unless new technologies can be developed. For example, chemotherapy is one of the main approaches in cancer treatment. It is basically a strategy of "combat poison with poison", using highly toxic chemicals to kill cancer cells. It kills cancer cells, but also kills normal cells of the patient. It is worthy of note that the strategy of using highly toxic chemical to "kill" the target is used not only in anticancer but also in antivirus and antibacterial therapies. These toxic chemicals have induced drug resistance in these organisms too, and this is the cause of the recent occurrence of "super bacteria".

The high toxicity of the current anticancer drugs often causes fatal side-effects in the patient and also the drug resistance of cancer cells. All these together resulted in the failure of cancer therapy for the last 50 years. Nanotechnology provides a promising way to overcome these fatal issues of traditional anticancer medicines. For example, the cisplatin is commonly used to treat prostate cancer at the clinic. However, the ability of prostate cancer cells to become resistant to cisplatin remains a significant impediment to successful chemotherapy of prostate cancer patients. One of main mechanisms by which cancer cells become resistant to cisplatin is the accumulation defects. The CP-r cells have a defect in endocytosis, which may lead to diminished accumulation of cisplatin and confer resistance to cisplatin. Recently, we found that the endocytosis of transferrin could be restored by fullerenol nanoparticles $[Gd@C_{82}(OH)_{22}]_n$, the nanoparticles can circumvent the acquired resistance of the CP-r PC-3-luc variants by enhancing uptake of cisplatin. Cisplatin sensitivity was also increased by nanoparticles in CP-r KB-3-1 and BEL 7404 cells. Because drug accumulation is reduced in CP-r cells due to a pleiotropic defect, other mechanisms such as reduced fluidity of plasma membrane or altered cytoskeleton may also contribute to the $[Gd@C_{82}(OH)_{22}]_n$ nanoparticle reversal of the cisplatin resistance. Moreover, these nanoparticles are surprisingly non-toxic to cancer cells *in vitro*, yet can successfully enhance the use of cisplatin on suppressing tumor growth *in vivo*. Using nanomaterials to overcome the drug resistance of malignant tumors could lead to new therapies for cancer patients, e.g., a promising chemotherapeutic method to treat tumors at lower, non-toxic dose levels (see the cover picture, and *PNAS*, 2010, 107: 7449–7454).

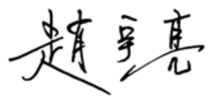
Cancer nanotechnology represents an innovative trend and aims at safe chemotherapy in cancer treatment. There are two research directions in cancer nanotechnology, one is to develop manufactured nanoparticles as carriers to improve the performance of current anticancer drugs (for example, see *PNAS*, 2010, 107: 7449–7454, etc.), in which the most important idea is that these nanosystems developed can help to solve one or more of the most challenging and longstanding problems in cancer therapy. The other is to develop nanoparticles directly as the novel anticancer medicines (for example, see *Nano Letters*, 2005, 4: 2050–2057; *ACS Nano*, 2010, 4: 2773–2783; *ACS Nano*, 2010, 4:

1178–1186, etc.). This was so far not but is becoming the mainstream in the field of cancer nanotechnology

Though cancer nanotechnology provides intriguing opportunities, there are still ten major challenges in cancer nanotechnology: (1) To deliver nanoparticles to the right place in the body (such as the tumor site), and to control the release of the nanoparticles; (2) to utilize nanoparticles directly as the cancer medicine, which will allow simpler, more efficient, and easier to control systems with lower toxicity and proper dosage sizes; (3) to use nanoparticles to enhance the performance of current medicines; (4) to develop multifunctional therapeutics; (5) to track and quantify nanoparticles in specific organs in the body; (6) to prevent nonspecific protein adsorption of the nanoparticles and consequent aggregation *in vivo*; (7) to develop personalized treatments for cancer patients; (8) to establish a systematic knowledge framework for nanotoxicology to understand the long-term effects of nanoparticles *in vivo*; (9) to communicate with the public about safety/ethical concerns, and avoid misconceptions, which magnify the risk of nanomedicine; (10) to develop standardization, a regulatory framework, and policy to facilitate governance and approval systems, which will lead to sustainable development.

Interestingly, the scientists who initiated the studies and made significant contributions and progress in this emerging discipline, which may reinvigorate the development of cancer therapies and diagnoses, are mostly from the disciplines of chemistry, physics, and nanoscience. However, scientists from biology, medicine, and oncology are now joining this exciting field of smart technologies.

We hope this special issue can provide you with some key information that may initiate your own study of the monumental issues associated with cancer treatment and diagnosis.



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