Editorial

Plasma Processes and Polymers Third Special Issue on Plasma & Cancer

Guest Editors:

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This issue of Plasma Processes and Polymers is the third in a series of special issues on the applications of low temperature plasma (LTP) against cancer, or "plasma oncology". The papers in this issue are inspired from the talks given at the third International Workshop on Plasma for Cancer Treatment (IWPCT) which took place on April 11-12, 2016 in Washington, DC, USA. IWPCT is an international workshop that was created in 2014 as a venue to share cutting edge plasma oncology research. The first IWPCT was held in Washington DC, under the co-chairmanship of Prof. Mounir Laroussi (Old Dominion University) and Prof. Michael Keidar (George Washington University). The second workshop, IWPCT-2, was held in March 2015 in Nagoya, Japan under the chairmanship of Prof. Masaru Hori (Nagoya University). As mentioned above, IWPCT-3 was held again in Washington DC in 2016 under the co-chairmanship of Dr. Jerome Canady (Jerome Canady Research Institute) and Dr. Jonathan Sherman (George Washington University).

The application of LTP in the field of oncology is a topic of growing importance within the discipline of Plasma Medicine. Plasma Medicine is an interdisciplinary field of research that emerged in the mid-1990s when seminal investigations showed that LTP can effectively inactivate various bacteria genera [1]-[4]. This early research quickly expanded to determining the effects of LTP on eukaryotic cells, first for wound healing [5]-[8] and later for cancer treatment applications [9]-[17]. Figure 1 shows a brief summary of the timeline and progress of the field of plasma

medicine for the past two decades. This timeline relates the major milestones for low temperature atmospheric pressure plasma applications in biology and medicine and does not include thermal and low pressure plasma works.

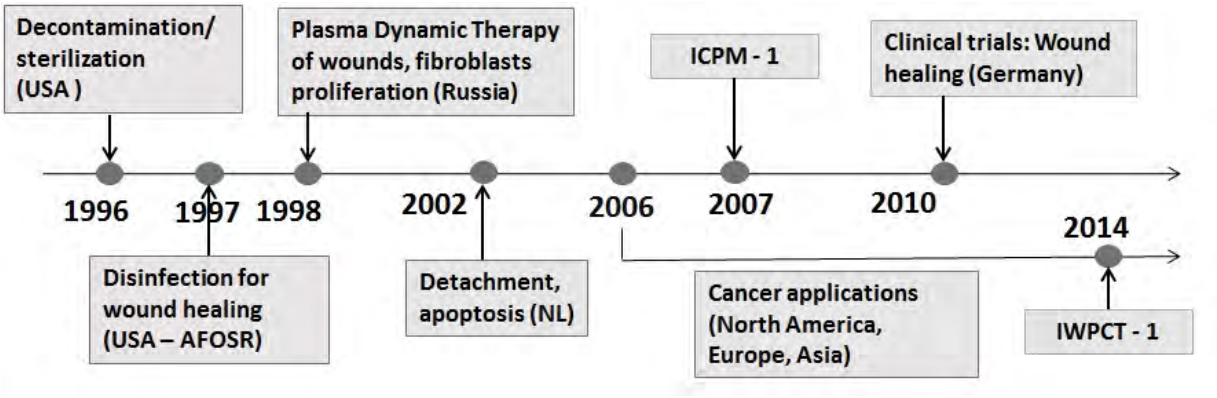

Fig. 1 Timeline showing the progression of plasma medicine. By the time this special issue is published, cancer related plasma research would have been ongoing for one decade (starting around 2006). The first conference entirely dedicated to plasma medicine was the International Conference on Plasma Medicine (ICPM) that was established in 2007. In 2014, a workshop entirely dedicated to LTP cancer applications was founded. This International Workshop on Plasma for cancer Treatment (IWPCT) meets annually. Many of the papers published in this special issue are inspired from talks given at the IWPCT-3 (2016).

Starting around the mid-2000s several investigators reported on successful studies which showed that low temperature plasmas can destroy cancerous cells *in vitro* [9]-[14]. By 2010, some *in vivo* work was reported which showed that plasma can reduce the size of cancer tumors in animal models [15]-[17]. The mechanisms of action of LTP on cancer cells include the induction of apoptosis via caspases or mitochondrial dysfunction, cell cycle arrest at the S-phase, DNA damage/double-strand breaks, and increase of the intracellular concentrations of ROS above tolerable thresholds. Investigators reported that reactive oxygen species, ROS, produced by the plasma are implicated in the initiation of these effects on cells/biomolecules in general and cancer cells in particular [7], [8], [13], [14], [18], [19]. The plasma-produced ROS have been implicated in penetrating the cells and inducing secondary reactions within the cells and/or triggering cell

signaling cascades involved in processes such as apoptosis that ultimately lead to the death of cancer cells. More importantly, under optimal conditions, it appears that LTP preferentially kills cancerous cells while leaving healthy ones mostly undamaged. This selectivity is very crucial if LTP is to be considered as a viable technology for a new cancer therapy.

Eighteen invited talks were delivered at IWPCT-3 along with fourteen poster presentations. Researchers hailing from ten countries attended the workshop, which allowed for ample discussions and excellent collaboration opportunities. This special issue contains nine papers which cover fundamental studies on the effects of LTP on cancer cells as well as applied investigations that aim to evaluate the possibility of using LTP as a basis for a novel and effective cancer therapy. Several of these papers discuss the correlation between plasma chemistry (especially RONS production), the plasma induced chemistry in the aqueous phase, and the observed cellular effects, including the importance of specific reactive species such as singlet oxygen and hydrogen peroxide. There is also general consensus that many factors dictate the biological outcome after plasma exposure. Examples of some of these factors include plasma operating parameters such as feed gas, flow rate, and power, as well as biological factors such as cell line and concentration, medium chemical composition, and direct versus indirect exposure. In addition, plasma activated media (PAM) as an alternative to the direct plasma treatment approach is discussed in a couple of the papers. Evaluation of the efficacy of PAM against some cancer lines is presented, including the impact of storage and temperature.

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