Environmental Science & Technology

Viewpoint

pubs.acs.org/est

Airborne Particulate Matter and Innate Immunity Activation

S. Gangamma*

Department of Chemical Engineering, National Institute of Technology, Karnataka, Surathkal, India

Airborne particulate matter (PM) is a mixture of solid and liquid droplets suspended in air. PM consists of organic, inorganic, and biological components including viable or nonviable microorganisms, and fragments of microorganisms including toxic components such as endotoxin and mycotoxins. PM exposure is considered as an important factor in health effects associated with ambient air pollution, cigarette smoke, biomass burning smoke, occupational exposure, vehicular exhaust, animal farms, grain dust, and nanoparticles. Epidemiological studies have established the relationship between PM exposure and adverse health effects including mortality. To develop efficient interventions and control strategies to mitigate adverse health effects of PM exposure, the biological mechanisms underlying this relationship need to be understood. However, the biological pathway relating PM exposure with adverse health effects is poorly understood.

Variations in physical properties, chemical composition, sources and host susceptibility paint a diverse picture of health effects due to PM exposure. The physical and chemical properties of PM also vary spatially and temporally. The variability and diversity are considered as reasons behind the poor understanding of PM induced health effects. Moreover, this diverse and complicated picture divides the research on PM and PM induced health effects into many isolated cubicles and compartments. This in turn, refrains the researchers from addressing the health impact of PM on a common ground. Many of these PM compartments have different measurement and research methodologies. As a result, each compartment has a different set of researchers and the research outcomes are spread over a variety of scientific journals. For example, it is difficult to find a citation on studies related to cigarette smoke or occupational PM in an ambient PM research article.

However, there are many common traits among these seemingly different PM exposures and associated health effects. For example, enhancement in susceptibility to infection is observed separately for cigarette and biomass burning smoke exposures. Reduction in resistance to infections is also observed with exposure to diesel exhaust particles. Relationship between susceptibility to infection and tolerance to microbial component, such as endotoxin, is very well-known. Endotoxin tolerance is another common trait associated with exposure to occupational PM, farm environment and cigarette smoke. Epidemiological and clinical studies have demonstrated that systemic inflammation accompanies PM exposure in occupational settings, ambient environment and cigarette smoke. These common traits are difficult to comprehend with the diverse nature of the chemical components associated with each type of PM. Understanding these commonalities is vital because that may give additional insight into the underlying biological mechanisms of epidemiological observation on PM.

Advances made in biology and allied disciplines in the last two decades have made it possible to understand part of these commonalities. One of the important achievements of biology in last few decades is to understand how an organism recognizes the invading infectious agents. The immune-recognition systems are broadly classified into innate and adaptive systems. Innate immunity is the first and rapidly acting defensive system and is an important factor in stimulating the adaptive immune response. One of the basic mechanisms connecting these common traits could be activation and subsequent modulation of innate immunity by PM. Progress in recognizing the stimulation of adaptive immunity through innate immune system also has given insights into health effects due to PM exposure. Increase in susceptibility to infection is an important aspect of adverse health effects due to PM exposure. Down regulation of innate immunity due to PM exposure plays an important role in the increase of infections among the PM exposed subjects. Cigarette smoke is known to activate toll like receptor-4 (TLR4). Monocytes from smokers exhibit tolerance to endotoxin and are associated with increase in the infections. Diesel exhaust particles induce tolerance in macrophages and down regulate lung innate immunity system. Ambient PM in lungs can indirectly activate TLR4 and subsequently induce endothelial wall dysfunction. Childhood innate immune activation by PM is now understood to orient the adaptive immunity of the host which is hypothesized to be the reason behind low levels of allergic diseases.

However, the mechanism with which the PM activates innate immunity is not clearly understood. Initially many studies have

Received: August 29, 2012
Revised: September 18, 2012
Accepted: September 24, 2012
Published: October 4, 2012

shown that the biological components associated with ambient PM play a significant role in activating innate immunity. But it is also known that PM associated with ambient air environment, cigarette smoke, occupational environments and diesel exhaust can activate innate immunity receptors such as TLRs and NOD-like receptors (NLR).[1] In these cases, total proinflammatory response or TLR4 activation by PM is not fully explained by the biological content in PM. This indicates an existence of secondary mechanisms involved in the activation of the immune system.[1] Now it is known that many secondary mechanisms, independent of endotoxin, exist for TLR4 activation by PM. However, the roles of low levels of biological components of PM are not yet fully understood.[2]

There are still many intriguing questions yet to be answered in the innate immunity activation and modulation by PM.[1] Apart from that, the endotoxin tolerance due to PM exposure can be considered as a part of balancing act to regulate inflammatory response. Unregulated and excessive inflammatory responses to danger signals from environmental factors, such as PM, lead to injury to healthy cells. These excessive inflammation and tissue injury are causal factors for several inflammatory diseases.[3] On the other hand, PM induced tolerance indicates an immune-suppressive state which could lead to increase in susceptibility to infections. Therefore, for PM exposed population, protection from increase in susceptibility to infections and reduced inflammatory responses that protect from inflammatory diseases are two sides of a coin. But is there a balance between these two extremes?[3] How such a balance is achieved? Does any other mechanism exist in the host immune system to handle this intricate balance?[4,5] We need to wait, with fingers crossed, to know how biology and allied sciences solve these issues and what will be the implications of their findings for PM induced adverse health effects.

AUTHOR INFORMATION

Corresponding Author

*Phone: 0091824-2474000; fFax: 0091824-2474033; e-mail: gangamma@gmail.com.

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

The author acknowledges the support of Department of Science and Technology, Government of India (SR/S4/AS: 283/2007&SR/FTP/ES-40/2008) for preparing the manuscript.

REFERENCES

(1) Bauer, R. N.; Diaz-Sanchez, D.; Jaspers, I. Effects of air pollutants on innate immunity: The role of toll-like receptors and nucleotide-binding oligomerization domain–like receptors. *J. Allergy Clin. Immunol.* **2012**, *129*, 14–24.

(2) Gangamma, S. Airborne particulate matter and endotoxin associated proinflammatory response. *J. Allergy Clin. Immunol.* **2012**, DOI: 10.1016/j.aci.2012.07.033.

(3) Medzhitov, R. Origin and physiological roles of inflammation. *Nature* **2008**, *454*, 428–435.

(4) Warren, H. S.; Fitting, C.; Hoft, E.; Adib-Conquy, M.; Beasley-Topliffe, L.; Tesini, B.; Liang, X.; Valentine, C.; Hellman, J.; Hayden, D.; Cavaillon, J. M. Resilience to bacterial infection: Difference between species could be due to proteins in serum. *J. Infect. Dis.* **2009**, *201*, 223–32.

(5) Ayres, J. S.; Schneider, D. S. Tolerance of infections. *Annu. Rev. Immunol.* **2012**, *30*, 271–294.